

Rail to Digital automated up to autonomous train operation

WP5.1 – Documentation of use cases for automating functions

Annex 4: Use cases for automating functions

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TABLE OF CONTENTS

Table of Contents.....	2
1 Developed Use Cases	5
1.1 UC5.1-001: "Wake-up" / Initialization and perform auto-tests/self-tests for normal operation in GoA 3&4	5
1.2 UC5.1-002: Prepare passenger train (diesel)	9
1.3 UC5.1-003: Prepare train unit for a mission – Configure GoA automatically	12
1.4 UC5.1-004: Prepare train unit for a mission – select traction system automatically	15
1.5 UC5.1-005: Determine and select travelling direction	17
1.6 UC5.1-006: Enter ATP data automatically	19
1.7 UC5.1-007: Prepare train for departure	21
1.8 UC5.1-008: Conduct visual inspections and tests.....	24
1.9 UC5.1-009: Conduct system and functional tests	26
1.10 UC5.1-010: Report end of shift / assignment.....	29
1.11 UC5.1-011: Stable a train unit – determine detrainment – automatic.....	32
1.12 UC5.1-012: Leave train in ready mode	34
1.13 UC5.1-013: Leave train in sleep mode	35
1.14 UC5.1-014: Perform mission	36
1.15 UC5.1-015: Skip station by passenger service	38
1.16 UC5.1-016: Implementing discretionary stops by regional services	40
1.17 UC5.1-017: Handle missed braking or target point	42
1.18 UC5.1-018: Set train into service.....	44
1.19 UC5.1-019: Stop at platform for passenger service	45
1.20 UC5.1-020: Manage Platform Screen Doors by ATO	47
1.21 UC5.1-021: Pass through voltage transition area or phase separation area	49
1.22 UC5.1-022: Pass a bridge without overhead line.....	51
1.23 UC5.1-023: Manage daily interior cleaning, end of line.....	53
1.24 UC5.1-024: Prepare the train set for maintenance - Perform various maintenance tasks in parallel	55
1.25 UC5.1-025: Drive train through washing station	58
1.26 UC5.1-026: Drive through anti-icing station	60
1.27 UC5.1-027: Operate Full autonomous trains at low speed <= 30km/h in stabling yard or shunting Area equipped or not with ETCS infrastructure	62
1.28 UC5.1-028: Prepare train for cleaning during shunting	65
1.29 UC5.1-029: Perform transition from CBG to NCBG	67
1.30 UC5.1-030: Perform transition from NCBG to CBG	69

1.31	UC5.1-031: Border crossing	71
1.32	UC5.1-032: Inspection Train: Elaborate mission and journey profiles including inspection activities	72
1.33	UC5.1-033: Inspection Train: Arriving at the starting point of the area to be inspected	75
1.34	UC5.1-034: Inspection Train: Finishing the inspection, retract devices, check data and prepare to return	77
1.35	UC5.1-035: Perform automatic train shunting and "special" movements: Non-scheduled stop, stop at next emergency stop area.....	79
1.36	UC5.1-036: Manage Train – Train collision.....	82
1.37	UC5.1-037: Handle hot wheel due to brake failure - Brake failure detected through hot boxes detector: continue to next station	84
1.38	UC5.1-038: Handle hot wheel due to brake failure - Brake failure detected through hot boxes detector: stop immediately	87
1.39	UC5.1-039: Handle hot wheel due to brake failure - Brake failure through train outside observation: stop immediately	91
1.40	UC5.1-040: Manage fire on-board locomotive or empty passenger train	95
1.41	UC5.1-041: Handle fire accident on passenger train – In station (at standstill)	98
1.42	UC5.1-042: Handle fire accident on passenger train – Running	101
1.43	UC5.1-043: Handle fire alarm tunnel - Fire alarm systems tunnel – No train unit run affected	106
1.44	UC5.1-044: Handle fire alarm tunnel - Fire alarm systems tunnel – At least one train unit affected	109
1.45	UC5.1-045: Handle failure of tilting technology infrastructure - Malfunction	113
1.46	UC5.1-046: Handle failure of equipment or situations in passenger cabin – Suspension failure	115
1.47	UC5.1-047: Handle infrastructure restrictions ordered by authorities – Bomb alarm on train	117
1.48	UC5.1-048: Handle stop train unit due to security incidents on-board – Identification of personal details.....	122
1.48.1	UC5.1-048A: Incident reported to RU/IM actors	122
1.48.2	UC5.1-048B: Incident reported to third actor (police)	124
1.49	UC5.1-049: Handle overcrowded train unit.....	127
1.50	UC5.1-050: Handle panic situation or riot in the train - in station detected by on-board systems	130
1.51	UC5.1-051: Handle panic situation (stampede) or riot in the train - in station detected by external actor	133
1.51.1	UC5.1-051A: External Actor is Passenger	133
1.51.2	UC5.1-051B: External Actor is Train Attendant	136
1.52	UC5.1-052: Handle panic situation (stampede) or riot in the train - during train unit run detected by on-board systems	138

1.53	UC5.1-053: Handle panic situation (stampede) or riot in the train - during train unit run detected by external actor	141
1.54	UC5.1-054: Emergency on train – In station	145
1.55	UC5.1-055: Person in passenger cabin needing medical assistance, detected by actor	150
1.56	UC5.1-056: Handle rescue operation affecting platform – Rescue operation on platform	155
1.57	UC5.1-057: Evacuation and emergency procedures: Detrainment procedures.....	158
1.58	UC5.1-058: Handle emergency triggered by passenger doors not detected as closed and locked (at passenger exchange position)	161
1.59	UC5.1-059: Handle emergency triggered by passenger doors not detected as closed and locked (not at passenger exchange position)	163
1.60	UC5.1-060: Moving passenger train with open doors – GoA3	165
1.61	UC5.1-061: Moving passenger train with open doors – GoA4	168
1.62	UC5.1-062: React to cargo irregularities.....	171
1.63	UC5.1-063: Handle door malfunction in Locomotive / Multiple.....	174
1.63.1	UC5.1-063A: Train attendant on board (GoA3).....	174
1.63.2	UC5.1-063B: Handle door malfunction in Locomotive / Multiple – Train unit not staffed (GoA4)	177
1.64	UC5.1-064: Resolving a detected HVAC failure at a platform.....	181
1.65	UC5.1-065: Restricting train operations due to detecting the derailment of another train	184
1.66	UC5.1-066: Handle overcrowded platform in station detected by actor.....	187
1.67	UC5.1-067: Emergency triggered by platform screen doors not detected as closed and locked (at passenger exchange position)	189
1.68	UC5.1-068: Emergency triggered by passenger screen doors not detected as closed and locked (not at passenger exchange position)	191
1.69	UC5.1-069: Handle bad current collection in case of weather conditions (wind, temperatures, etc.).....	193
1.70	UC5.1-070: Apply temporary Speed Restrictions for High Winds	195
1.71	UC5.1-071: Restricting train operations due to unauthorized escape door opening (in tunnel)	198
1.72	UC5.1-072: Restricting train operations due to detected trespassing	200
1.73	UC5.1-073: Set low adhesion conditions	203
1.74	UC5.1-074: Deregister a vehicle from operation in the AoC	205

1 DEVELOPED USE CASES

1.1 UC5.1-001: "WAKE-UP" / INITIALIZATION AND PERFORM AUTO-TESTS/SELF-TESTS FOR NORMAL OPERATION IN GoA 3&4

Use case field	Description
ID	UC5.1-001
Use case name	"Wake-up" / Initialization and perform auto-tests/self-tests for normal operation in GoA 3&4
Main actor	<ul style="list-style-type: none"> • OAS (On-board Automation System) • FMS (Fleet Management System) • Railway Undertaking (RU)
Other actors	<ul style="list-style-type: none"> • Train Unit • ATP • APM
Use case summary	<p>This use case describes the needs and the possible solution to switch on the train automatically. The "cold train" in "switch off" mode (battery off) is out of scope because the cold train can only be awakened manually. The OAS system shall execute automatically (without requiring additional action by staff) wake-up and self-tests procedures.</p> <p>Automating this task is not only beneficial to train driver and/or on-board staff, but also for energy saving by adaptive wake-up time according to the weather, temperature, and train type.</p>
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA3, GoA4 • Operational category: passenger, freight, urban, regional, mainline and inspection vehicles
Main goal	<ul style="list-style-type: none"> • Ensure all on-board systems powered on with correct timing. and ascertain whether the train can be operated, suitable for service, and has no adverse impact on connected systems.
Preconditions	<ul style="list-style-type: none"> • Train is parked below the catenary in case of electric train and in the same position where finished the last mission and confirmed standstill (cold movement detector) • The radio communication channel between train and trackside (RU control centre) is always on, which requires the mobile router on-board is always powered on. Therefore, the train can receive signals remotely from the RU control centre. • An on-board health monitoring system (e.g., temperature monitoring, batter monitoring, mobile router, etc.) is always needed for any ATO trains, therefore such on-board health monitoring system needs to be always powered on. • The driving mode controller/switch is set to "Automatic Mode" in all the driver's desks of the train (e.g., both ends of a multiple unit, the four driver's desks of two coupled multiple units, all driver's desks of the locomotives in the composition, etc.).

	<ul style="list-style-type: none"> • ETCS and OAS (TCMS) are fully operational for starting the ATO module: <ul style="list-style-type: none"> ○ Self-tests/auto-tests: OAS (TCMS) determines the status of the rolling stock (integrity of the train, train's doors status, possible faults on auxiliary systems, etc.). Rolling stock auto tests of the different subsystems + visual inspections (from humans or robots) contribute to determine the status. Control centre, based on OAS (TCMS) summary and human/robot visual inspection, determines to continue the sequence to check if the ETCS is located. • ETCS is located: <ul style="list-style-type: none"> ○ Case of ERTMS L2 <ul style="list-style-type: none"> a) Train is located and ETCS is connected/registered with the RBC (at least via GSM-R, ideally via FRMCS if available). b) If the train is unlocated, the train must be manually or remotely controlled until the train is located and connection is established with the RBC (at least via GSM-R, ideally via FRMCS if available). Then, the train to has stop (parking brake) and remain standstill (cold movement detector). ○ Case of ERTMS L1 <ul style="list-style-type: none"> a) Train is "approximately" located from track circuits or axle counters. Manual driving or remote driving until the next fixed balise for precise location. Then, the train must stop (parking brake) and remain standstill (cold movement detector). b) If the train is completely unlocated, the train has to be manually or remotely driven until the train is located. Then, the train must stop (parking brake) and remain standstill (cold movement detector). c) Alternate case: If the train was precisely located when it was parked (e.g., thanks to a digital map) at the end of the previous commercial service, without a warning from the cold movement detector between the previous operation and current one, the location might be "recovered" If the ETCS verifies that the doppler radar absolute counter value didn't change. • ETCS checks prior to authorize "Automatic Mode": <ul style="list-style-type: none"> ○ ETCS checks that the train is standstill (cold movement detector) and precisely located. ETCS connection with RBC is established in case of ERTMS L2. ○ ETCS checks that the driving mode controller/switch in the driver's desks is set to "Automatic Mode". ○ ETCS receives the status of the train based on self-tests/auto-tests (control centre checks OAS (TCMS) report and considers results from visual inspections). 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Train is awakened and ready to start the mission.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Train awake sequence/initialization failed and train is not ready to start de mission due to: <ul style="list-style-type: none"> ○ Any self-check failed. ○ Communications failed.

<p>Condition affecting termination outcome</p>	<p>Outcome 1</p>	<ul style="list-style-type: none"> • Maintenance work should be protected. No matter to protect maintainers or to protect software update without interruptions. • During the maintenance working time, any unauthorized wake-up command from RU centre should be prevented, or any preconfigured wake-up time neither from RU centre nor by train driver should be modified or removed.
<p>Use case scenario</p>	<p>Step 1</p>	<p>Based on the planning, the “ready for service time” can either be sent by a command from RU control centre to Rolling Stock automatically or be pre-configured in Mission Profile and stored on-board.</p> <p>If there is any change of planning (for example by temporary maintenance requirement, cancellation of the operation for various reasons or railway strike), only the RU control centre can send commands to update the wake-up time stored on Rolling Stock.</p>
	<p>Step 2</p>	<p>Powering vehicle depending on its initial state, type of vehicle and the presence of a contact line or not.</p> <p>The initial power supply information upon train power-up for electrical train can be managed in two different ways:</p> <ul style="list-style-type: none"> • OAS (TCMS) checks (with track information stored in OAS (REP)) if contact line is powered on with the correct voltage supply. • OAS (TCMS) continuously supervises the battery and automatically connects to contact line to recharge the battery if necessary. When it is connected, either traction power system detects on its own what current type is feed through the contact line or OAS (TCMS) remembers the last value. • In case the OAS (TCMS) functions are not available, or the train is completely powered down, OAS (APM) memorizes the last traction system setting from the segment profile used upon arrival at the parking position.
	<p>Step 2.1</p>	<p>In overhead contact line, raise pantograph if necessary. Electric trains require to raise the pantograph with pneumatic pressure assisted by batteries. Self-propelling trains require a signal to start.</p>
	<p>Step 2.2</p>	<p>Powering on-board modules (Train Protection, OAS (ADM, REP, PER, APM). All are in NP (No Power) State and will change to:</p> <ul style="list-style-type: none"> • AV (Available) for OAS (APM) • NA (Not Available) for OAS (PER and REP)* • CO (Configuration) for OAS (ADM) • SB (Stand by) for Train Protection

	Step 2.3	Check new state of all modules.
	Step 2.4	Powering auxiliaries.
	Step 3	Based on the given “ready for service time”, the train health monitoring system evaluates the environment (e.g., temperature and battery) to decide the optimal time to wake up other on-board systems, such as comfort systems for pre-heating or pre-cooling, lightening system, OAS (ATP), OAS (ADM), passenger information system, etc.
	Step 4	Check inside temperature and heat or cool down before embarkment of passenger.
	Step 5	When the "Automatic Mode" is authorized on-board of the train after the ETCS checks, the OAS (ADM) is initialized, connected to the radio link (at least GSM-R, ideally FRMCS) and set "to Automatic Mode" (for GoA 3-4). OAS(ADM) should complete transition to RE state according to Table 8.2 and 8.3 of SRS 0.3.0.
	Step 6	Self-test according to the type of train (like Brake, ATP, passenger information system, doors, heating, cooling, train head lights on both ends, battery voltage, sanding facilities, contact line connection and ...) to be sure that all on-board equipment are available and operational.
	Step 7	Train awaked up and the OAS (ADM) is ready to control train operation as all technical and operational conditions for engagement are fulfilled but the OAS(ADM) is waiting for driver action to start automatic driving (8.4.2.6.1 SRS 0.3.0).
Postcondition		Rolling stock (e.g., OAS(TCMS), comfort systems) is powered on. Connected to Contact line, main switch is closed, battery loaded. <ul style="list-style-type: none"> • OAS (ADM) and applicable conditions for ATO Operational are fulfilled (8.4.2.10.2 SRS 0.3.0). • ATO Up to GoA3&4 On-board is powered on and in RE state.
Use case notes		Related use cases: R1 Automatic train wake up (Baseline 0.1): <ul style="list-style-type: none"> • 13.3.1 Awakening sequence of autonomous train (SRS 0.3.0) * REP and PER states were defined in UC 13.3.1

Table 1: Use case "Wake-up" / Initialization and perform auto-tests/self-tests for normal operation in GoA 3&4" description

1.2 UC5.1-002: PREPARE PASSENGER TRAIN (DIESEL)

Use case field	Description	
ID	UC5.1-002	
Use case name	Prepare passenger train (diesel)	
Main actor	<ul style="list-style-type: none"> • Remote Driver • Train Preparation Staff (TPS) 	
Other actors	<ul style="list-style-type: none"> • Railway Undertaking Supervisor (RUS). • Physical Train Unit • Trackside Automation System (TAS). • On-board Automation System (OAS). • Fleet Management System (FMS) 	
Use case summary	This scenario outlines the process of getting a passenger train ready for operation, particularly one powered by diesel. The main goal of this train preparation is to guarantee the safety of the rail vehicles and ensure they are set up correctly to enter the rail network.	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: OAS, TAS, FMS. • Operational categories: passenger, freight, urban, regional, mainline, and inspection vehicles. 	
Main goal	Facilitate a future solution to prepare a passenger train (diesel) for service.	
Preconditions	<ul style="list-style-type: none"> • The train is completely stopped and parked. According to Operational Scenario <i>13.2.5 Park autonomous train</i>. • The train environment is free of obstacles: <ul style="list-style-type: none"> • No persons around the train. • No external equipment and systems connected to the vehicle, or in the path of the vehicle. • No scheduled maintenance tasks. • Train Protection, ADM, REP, PER, and APM → NP State (No Power). • TCMS → Shutdown. • The radio communication channel between the train and trackside (RU control centre) is always on, which requires the mobile router on-board is always powered on. Therefore, the train can receive signals remotely from the RU control centre. • An on-board health monitoring system (e.g., temperature monitoring, batter monitoring, mobile router, etc.) is always needed for any ATO trains, therefore such on-board health monitoring system needs to be always powered on. 	
Termination outcome	Successful outcomes	The train is secure and fit for service and the Operational Scenario <i>13.3.1 Awakening sequence of autonomous train</i> is ready to be initiated.
	Unsuccessful outcomes	The checking and testing of equipment and systems fails therefore the train is not ready for service.

Condition affecting termination outcome	Outcome 2	When the train control unit is energized, it begins to automatically check and test of equipment and systems (doors, brakes, traction, lights, and other auxiliaries). During this process, the check can detect an error owing to a malfunction of the equipment or system.
Use case scenario	Step 1	TPS notifies the FMS that the train is secure and fit for service.
	Step 1.1	FMS receives the TPS notification and sends the notification to the RUS.
	Step 1.2	RUS receives the notification and manages the train awakening via a short message sent through C48 interface that permits to close the main switch with train battery. <i>Note: General Principle 7.3.3.1.2 from Deliverable D5.1 WP5 GoA3/4 Specification)</i>
	Step 1.3	OAS (TCMS) changes train mode to remote control and sends confirmation to Train management
	Step 2	X2Rail-4 Operational Scenario 13.3.1 <i>Awakening sequence of autonomous train.</i> Train Protection → SB (Stand-By) State ADM → CO (Configuration) State REP, PER → NA (Not Available) State APM → AV (Available) State. TCMS → SwitchOn
	Step 3	OAS checks new state of all modules.
	Step 4	Perform brake test. This step depends on the type of the train: <ul style="list-style-type: none"> • The train is equipped with an automated brake test system. Proceed to Step 4.1. • TPS is responsible for performing the test via stationary test device. Proceed to Step 4.2.
	Step 4.1	If the train is equipped with an automated brake test system, the Remote driver requests to complete the brake test and change the state to “Automatic Brake test completed” reached. The automated brake test system will start the compressed air system and check that the pressure is correct.
	Step 4.1.1	OAS collects the brake sheet relevant data.

	Step 4.1.2	OAS generates/calculates the brake sheet.
	Step 4.2	TPS performs the brake test and changes the state to "Automatic Brake test completed" reached.
	Step 4.2.1	TPS collects the brake sheet relevant data.
	Step 4.2.2	TPS generates/calculates the brake sheet.
	Step 5	OAS (APM) sends notification: "Technical wagon inspection, brake test, and brake sheet ok".
Postcondition	Subsequently, the train startup sequence was initiated. This sequence depends on the model and series of the train. For example, as a recommendation for a diesel train, the motor-alternator group must be started first to have 400 V AC, and therefore, battery charge.	
Use case notes	<p>Related use cases:</p> <p>X2Rail-4 Deliverable D5.1 WP5 GoA3/4 Specification (SRS 0.3.0):</p> <ul style="list-style-type: none"> • 13.3.1 Awakening sequence of autonomous train. 	

Table 1: Use case "Prepare passenger train (diesel)" description

1.3 UC5.1-003: PREPARE TRAIN UNIT FOR A MISSION – CONFIGURE GoA AUTOMATICALLY

Use case field	Description	
ID	UC5.1-003	
Use case name	Prepare train unit for a mission - Configure GoA automatically	
Main actor	OAS	
Other actors	<ul style="list-style-type: none"> • TAS • IM • FAS • RU 	
Use case summary	<p>After powering on the train, Trackside Automation System provides the Onboard Automation System with all profiles needed for the mission.</p> <p>There are three sources for GoA:</p> <ol style="list-style-type: none"> 1. Static track plan data (static Segment Profile). 2. Dynamic information from dynamic Segment Profile from IM (OE). 1. Dynamic information from Mission Profile from RU. 	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA3/4 • Operational category: passenger, urban, regional, mainline 	
Main goal	Prepare the train for mission by providing all the necessary data and profiles. The GoA level is configured accordingly	
Preconditions	<p>Train is in one of the following modes:</p> <ul style="list-style-type: none"> • Service Retention mode • Standby mode • Energy Saving mode • Shutdown mode. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • OAS has all data and profiles needed for the mission. OAS has configured the correct GoA
	Unsuccessful outcomes	<ul style="list-style-type: none"> • The train is not ready for operation as some necessary data is missing. This can be due to communication problems or invalid/missing data.
Condition affecting termination outcome	Outcome 2	<ul style="list-style-type: none"> • Connection problems • Invalid / missing GoA configuration data.
Use case scenario	Step 1	The RU prepares the Mission Profile (MP) and the Train Data (TD)

Step 2	The IM prepares the Journey Profiles (JP) and the Digital Map (DM)
Step 3	Awakening of the train according to: <ul style="list-style-type: none"> • “UC5.1. ADIF-4.1: "Wake-up" / Initializacion for normal operation in GoA 3&4 • “UC5.1. MK-OS-2: Switch on train”
Step 4	The train is awake.
Step 5	OAS establishes communication with FAS located in RU center, hosting MP/TD (RU server).
Step 6	OAS requests the Mission Profile (MP).
Step 7	FAS provides the Mission profile (MP).
Step 8	OAS requests the Train Data (TD).
Step 9	FAS provides the Train Data (TD).
Step 10	OAS establishes communication with TAS (IM server) hosting the Journey Profiles (JP) and the Digital Map (DM).
Step 11	OAS extracts Train Running Number and request Journey Profiles (JP) and the Digital Map (DM) from TAS.
Step 12	TAS provides the Journey Profiles (JP) and the Digital Map (DM).
Step 12.1	OAS requests new data or an update, if any of the received data is unavailable or invalid respectively.
Step 12.1.1	Unsuccessful outcome if no valid data could be provided. Else Continue with Step 13.
Step 13	OAS evaluates the validity of the GoA configuration data it received and reports anomaly to TAS (or IM) and FMS (or RU).
Step 13.1	OAS reports to TAS if the conditions for setting the specified GoA level are not fulfilled (e.g GoA4 is specified, but there is someone present in the driver’s cab). Continue to Step 14 once the conditions are fulfilled.
Step 14	OAS sets the GoA level according to the profiles it has received and the available on-board GoA level.
Postcondition	OAS has all data and profiles needed for the mission. OAS has configured the correct GoA.
Use case notes	This use case is related to the following X2Rail-4 ATO specifications:

	<ul style="list-style-type: none"> • SRS v0.3.0, chapter 8.1, especially Table 8.1 • ATO (up to GoA4): COMMUNICATION SESSION MANAGEMENT PRINCIPLES • SRS UCs 13.2.1 Elaborate mission and journey profiles. • SRS UCs 13.2.7 Validate human interaction. • SRS UCs 13.3.2 Operations to test safety contributors. • SRS UCs 13.3.4 Train protection configuration. • SRS UCs 13.5.1 Prepare freight train. • ATO Operational Scenario v1.12: R3 Prepare train for mission,
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Table 1: Use case “Prepare TU for a Mission - Configure GoA automatically” description

1.4 UC5.1-004: PREPARE TRAIN UNIT FOR A MISSION – SELECT TRACTION SYSTEM AUTOMATICALLY

Use case field	Description	
ID	UC5.1-004	
Use case name	Prepare train unit for a mission – Select traction system automatically	
Main actor	Fleet Automation System (FAS)	
Other actors	<ul style="list-style-type: none"> On-board Automation System (TCMS, ATO, ETCS) (OAS) Trackside Automation System (TAS) Fleet Manager Operations Manager Serviceable train 	
Use case summary	<p>The use case, Prepare Train unit for a Mission, normally happens after the X2Rail-4 use case “Awakening sequence of autonomous train” and the originally identified use case “Switch traction power supply to a train unit while stationary” is part of this use case. The selection or the switch of traction power supply is expected to be automatic to:</p> <ul style="list-style-type: none"> Select voltage level. Select voltage type in the catenary. React on powerless section. 	
Applicability	<ul style="list-style-type: none"> Geographical: European level System level: GoA3, GoA4 Operational category: passenger, freight, urban, regional, mainline and inspection vehicles 	
Main goal	Traction power supply is selected successfully	
Preconditions	<ul style="list-style-type: none"> Train is stationary, or the train is moving and under powerless section. Pantograph and main switch fully operational. The On-board Automation System with subsystems like TCMS, ATO and ETCS fully operational. The Trackside Automation System fully operational. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> Outcome 1: Traction power supply is selected successfully (pantograph up, main switch closed, traction available, connected to catenary power)
	Unsuccessful outcomes	<ul style="list-style-type: none"> Outcome 2: Traction power supply fails in selection. Outcome 3: OAS receives invalid data about Infrastructure ID or type of traction power system and cannot select traction power system
Condition affecting termination outcome	Outcome 2	<p>Explanations for unsuccessful outcome:</p> <ul style="list-style-type: none"> Failure in pantograph (pantograph unable to be up or down, pantograph unable to detect voltage and frequency of the catenary). Failure in catenary (powerless catenary). Failure in main switch. <p>Post-conditions for unsuccessful outcome:</p> <ul style="list-style-type: none"> Serviceable train has no power. If the train is in Standstill: OAS applies parking brakes. Inform the power supply abnormal to Trackside Automation System and Fleet Automation System.

		<ul style="list-style-type: none"> Inform the power supply abnormal to Operations Manager, Fleet Manager and Railway Undertaking Supervisor. And they coordinate whether traffic schedule to be modified and whether maintenance is organised.
	Outcome 3	<p>Explanations for unsuccessful outcome:</p> <ul style="list-style-type: none"> Invalid data about Infrastructure ID or type of traction power system sent by TAS. <p>Post-conditions for unsuccessful outcome:</p> <ul style="list-style-type: none"> OAS asks TAS to resend valid data about Infrastructure ID and type of traction power system.
Use case scenario	Step 1	FAS sends Infrastructure ID and type of traction power system to OAS.
	Step 2	OAS selects train parameters according to Infrastructure ID and type of traction power system.
	Step 2.1	OAS cannot select train parameters because of invalid data from FAS. OAS informs FAS about invalid data (Outcome 3).
	Step 3	OAS activates respective traction power devices.
	Step 4	OAS rises pantograph.
	Step 4.1	If the pantograph is abnormal, OAS informs TAS and FAS (Outcome 2).
	Step 5	OAS detects the voltage and frequency of the catenary.
	Step 5.1	If OAS detects abnormal catenary, OAS and informs TAS and FAS (Outcome 2).
	Step 6	Voltage and frequency detection is normal.
	Step 7	OAS releases the required traction system.
	Step 8	OAS activates main switch.
	Step 8.1	If the main switch is abnormal, OAS informs TAS and FAS (Outcome 2).
	Step 9	OAS reports 'train ready to move' to FAS.
Postcondition	<ul style="list-style-type: none"> Traction power is available. HVAC (Heating, Ventilation, Air Conditioning) is available. Serviceable train can start to prepare for journey. 	
Use case notes	<ul style="list-style-type: none"> Recommend having one general use case “Prepare Train Unit for a Mission”, rather than detail each task of this general use case. Modern vehicle can select the required traction system automatically. This function is available for train wake-up and during the operation (e.g., switch traction power supply at the country border). This function is available when the train is stationary or running. However, for modern vehicle with multiple units, it is unclear what is happening when only one of the units fails to select the correct traction system. When train at standstill, it is necessary to secure the train with parking brakes. 	

Table 2: Use case “Prepare TU for a Mission – select traction system automatically” description

1.5 UC5.1-005: DETERMINE AND SELECT TRAVELLING DIRECTION

Use case field	Description	
ID	UC5.1-005	
Use case name	Determine and select travelling direction	
Main actor	<ul style="list-style-type: none"> On-board Automation System (OAS) Fleet Management System (FMS) 	
Other actors	<ul style="list-style-type: none"> Trackside Automation System (TAS) Serviceable train 	
Use case summary	<p>A change of the travelling direction can happen in two cases:</p> <ul style="list-style-type: none"> Train preparation. A change in running direction requested by Mission Profile. <p>In both cases, it is necessary to enter the ATP data automatically (see 'UC5.1-006 Enter ATP data automatically').</p> <p><u>Select the correct cab:</u> The change of cab is initiated by the On-board Automation System (OAS) using Mission Profile, Journey Profile and Segment Profile (Digital Map Information). The Serviceable train shall know its last orientation from last journey. Then it can select the correct cab based on the new Journey Profile and Segment Profile (Digital Map Information).</p>	
Applicability	<ul style="list-style-type: none"> Geographical: European level System level: GoA3, GoA4 Operational category: passenger, freight, urban, regional, mainline and inspection vehicles 	
Main goal	<ul style="list-style-type: none"> The cab of Serviceable train is selected correctly. 	
Preconditions	<ul style="list-style-type: none"> Serviceable train is switched on. OAS fully operational. TAS fully operational. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> Outcome 1: Cab is selected correctly.
	Unsuccessful outcomes	<ul style="list-style-type: none"> Outcome 2: No cab or wrong cab is selected.
Condition affecting termination outcome	Outcome 2,3,4	<p>Explanations for unsuccessful outcomes:</p> <ul style="list-style-type: none"> Outcome 2: lack of sufficient inputs or wrong inputs for OAS to determine the correct cab for next journey. <p>Post-conditions for unsuccessful outcomes</p> <ul style="list-style-type: none"> Train will not be ready for departure.
Use case scenario	Step 1	OAS executes the mission profile. The mission profile contains a task "change cab" or "set train into service".
	Step 2	OAS determines the actual CAB by using Journey Profile, Segment Profile, Digital Map data, ETCS data, possible other data inputs such as physical sensors, data from previous journey. If not, OAS informs Fleet Automation System and TAS (Outcome 2).

	Step 3	Cab is selected correctly.
Postcondition	<ul style="list-style-type: none"> Other checks can be done to guarantee that the train is ready for departure. 	
Use case notes	<ul style="list-style-type: none"> This use case is also valid for freight train, even if its running direction cannot be changed, but its locomotives can be arranged at front or at end. And the locomotive of freight train may run as a single locomotive. This use case is related to the following X2Rail-4 ATO specifications: <ul style="list-style-type: none"> ATO Operational Scenario: R20 change running direction, SRS v0.2.4 UCs 13.3.4 "Train Protection configuration" and "Determine and select travelling direction". 	

Table 1: Use case “Determine and select travelling direction” description

1.6 UC5.1-006: ENTER ATP DATA AUTOMATICALLY

Use case field	Description	
ID	UC5.1-006	
Use case name	Enter automatically ATP data	
Main actor	<ul style="list-style-type: none"> On-board Automation System (OAS) (TCMS, ATO, ETCS) Fleet Automation System 	
Other actors	<ul style="list-style-type: none"> Trackside Automation System Serviceable train 	
Use case summary	<p>A change of the front end can happen in two cases:</p> <ul style="list-style-type: none"> Train preparation. A change in running direction requested by Mission Profile. <p>In both cases, it is necessary to enter the ATP data automatically.</p> <p><u>Enter the ATP data:</u></p> <p>If the correct cab is selected, or if the TCMS is connected to the waggons by using the Digital Automatic Coupler (DAC) a system can enter the train data in ATP.</p> <p>The train data is supplied by Fleet Automation System (FAS). OAS should check whether the input data from FAS has conflict with determined train local data. In EMUs this could be done by checking the inauguration data from TCMS. In freight trains it could be done by staff or by using the Digital Automatic Coupler (DAC).</p>	
Applicability	<ul style="list-style-type: none"> Geographical: European level System level: GoA3, GoA4 Operational category: passenger, freight, urban, regional, mainline and inspection vehicles 	
Main goal	<ul style="list-style-type: none"> The ATP data input is correct. 	
Preconditions	<ul style="list-style-type: none"> Serviceable train is switched on. The On-board Automation System with subsystems like TCMS, ATO and ETCS is fully operational. The Trackside Automation System fully operational. The cab of Serviceable train is selected correctly. TCMS is connected to all the waggons by using the Digital Automatic Coupler (DAC) 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> Outcome 1: The ATP data input is correct.
	Unsuccessful outcomes	<ul style="list-style-type: none"> Outcome 2: No train data available, or train data invalid, or unable to enter train data.
Condition affecting termination outcome	Outcome 2,3,4	<p>Explanations for unsuccessful outcomes:</p> <ul style="list-style-type: none"> Outcome 2: data input issue from Fleet Automation System. <p>Post-conditions for unsuccessful outcomes</p> <ul style="list-style-type: none"> Train will not be ready for departure. OAS informs Fleet Automation System of the data issues.

		<ul style="list-style-type: none"> OAS informs TAS that the data input issue might lead to potential delays.
Use case scenario	Step 0	OAS has selected and activated the correct cab
	Step 1	OAS requests train data from Fleet Automation System.
	Step 4	<p>OAS checks whether:</p> <ul style="list-style-type: none"> the input train data is received from Fleet Automation System the input train data matches the determined train local data. <p>If not, inform Fleet Automation System and inform TAS when necessary (Outcome 2).</p>
	Step 7	OAS executes activation confirmation. If the activation fails, OAS informs Fleet Automation System and inform TAS when necessary (Outcome 2).
	Step 8	The ATP data input data is correct.
Postcondition	<ul style="list-style-type: none"> Other checks can be done to guarantee that the train is ready for departure. 	
Use case notes	<ul style="list-style-type: none"> Safety aspects: ATP is (partially) a SIL4-system. It must be defined which SIL level the data entry is. Today it is done by the driver, which is not a SIL 4 system. 	

Table 1: Use case “Enter ATP data automatically” description

1.7 UC5.1-007: PREPARE TRAIN FOR DEPARTURE

Use case field	Description	
ID	UC5.1-007	
Use case name	Prepare train for departure	
Main actor	Fleet Management System (FMS)	
Other actors	<ul style="list-style-type: none"> • Train Preparation Staff (TPS) • Remote Driver (RDR) • On-board Automation System (OAS) • Fleet Manager (FM) 	
Use case summary	<p>This use case defines the steps to be completed to move the locomotive from the parking area to the wagon group. Two brake tests should be completed. The first locomotive should complete self-brake testing, once the locomotive is coupled with the wagon group, a second brake test should be completed. Train integrity and train composition should be checked before departure.</p>	
Applicability	<ul style="list-style-type: none"> • <i>Geographical: European Level</i> • <i>System level: OAS, Remote Driving</i> • <i>Operational categories: Mainline, freight, regional</i> 	
Main goal	Prepare the train for departure and start the mission.	
Preconditions	<ul style="list-style-type: none"> • Train ID, and Train Data defined by the Operations Manager. • The train is awakened according to <i>UC5.1-001: "Wake-up" / Initialization and perform auto-tests/self-tests for normal operation in GoA 3&4.</i> • Train is localized. • Vehicles (wagons or couches) have been checked by the train preparation staff (composition, integrity). • Fleet manager has generated the brake sheet for the train. • OAS and Remote Driver have received the mission data with the brake sheet. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Train ready for departure with brake test completed and train composition and train integrity checked.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Train not ready for departure.
Condition affecting termination outcome	Outcome 1	<ul style="list-style-type: none"> • Brake testing failure. • Train composition differs from mission data information. • Train integrity check failure.
Use case scenario	Step 1	Remote Driver requests train mastership (See 'UC.5.4.Mastership20' in task 5.4)
	Step 2	OAS changes train mode to remote control and sends confirmation to the Remote Driver.

Step 3	OAS indicates the presence of the locomotive to other vehicles switching on the lights.
Step 4	OAS activates perception modules including all the systems (cameras, LIDAR, radar, etc.)
Step 5	Remote Driver launches the brake tests for the rolling stock.
Step 6	OAS performs the brake test (specific to the rolling stock).
Step 6.1	(Brake test succeeded), OAS switches to “is prepared” mode and informs the Remote Driver.
Step 6.2	(Brake test failed), OAS remains in service mode and informs the Remote Driver.
Step 6.2.1	Remote Driver informs the Fleet manager -> Outcome 1.
Step 7	Remote Driver selects SH mode.
Step 8	Remote Driver requests video stream to OAS and OAS provides video stream to Remote Driver.
Step 9	Remote Driver requires traction to move forward/backward and requires service brake (apply/release) to move the train remotely with the aid of video stream to the wagon group. Localization system is operating and sending information to the Remote Driver (see UC.5.4.DepMan1 in task 5.4).
Step 10	Once the loco arrives at the wagon group the Remote Driver starts the coupling procedure.
Step 10.1	Remote Driver commands OAS to activate coupling mode.
Step 10.2	Remote Driver with OAS completes the coupling(See UC.5.4.DepMan2 in task 5.4).
Step 11	OAS checks coupling, train integrity, and train composition with the train data collected. In the case of freight trains without DAC (Digital Automatic Coupling), the Train Preparation Staff completes the coupling, train integrity, and train composition Remote Driver collects the necessary train data.
Step 12	Remote Driver launches the brake test depending on the mission (complete or simplified).
Step 13	OAS performs the brake test depending on the train type.
Step 13.1	(Brake test succeeded), OAS switches to “is prepared” mode and informs the Remote Driver.

	<table border="1"> <tr> <td>Step 13.2</td> <td>(Brake test failed), OAS remains in service mode and informs the Remote Driver.</td> </tr> <tr> <td>Step 13.2.1</td> <td>Remote Driver informs the Fleet manager -> Outcome 1.</td> </tr> <tr> <td>Step 14</td> <td>OAS or Remote Driver sends a notification: the train is ready for departure to the FM.</td> </tr> <tr> <td>Step 15</td> <td>FM issued the authorization for departure to OAS and the Remote Driver.</td> </tr> </table>	Step 13.2	(Brake test failed), OAS remains in service mode and informs the Remote Driver.	Step 13.2.1	Remote Driver informs the Fleet manager -> Outcome 1.	Step 14	OAS or Remote Driver sends a notification: the train is ready for departure to the FM.	Step 15	FM issued the authorization for departure to OAS and the Remote Driver.
Step 13.2	(Brake test failed), OAS remains in service mode and informs the Remote Driver.								
Step 13.2.1	Remote Driver informs the Fleet manager -> Outcome 1.								
Step 14	OAS or Remote Driver sends a notification: the train is ready for departure to the FM.								
Step 15	FM issued the authorization for departure to OAS and the Remote Driver.								
Postcondition	Train is ready for departure.								
Use case notes	<p>Related use cases:</p> <p>X2Rail-4 Deliverable D5.1 WP5 GoA3/4 Specification (SRS 0.3.0:</p> <ul style="list-style-type: none"> • 13.5.1 Prepare freight train • 13.12.1 Remote driving <p>TAURO:</p> <ul style="list-style-type: none"> • UC_005_109 Preparation for departure. <p>R2DATO - WP5 (task 5.4):</p> <ul style="list-style-type: none"> • UC 5.4.Mastership20 – Give control to remote operator.x.DrivingAtTractionChainLevel. • UC.5.4.DepMan1 – Depot Maneuver. • UC 5.4.DepMan2 – Joining/Splitting in the Depot. 								

Table 1: Use case “Prepare train for departure” description.

1.8 UC5.1-008: CONDUCT VISUAL INSPECTIONS AND TESTS

Use case field	Description	
ID	UC5.1-008	
Use case name	Conduct visual inspections and tests	
Main actor	Train driver (TD)	
Other actors	Driver helpdesk	
Use case summary	<p>As part of the protocol to prepare the train for departure, the driver needs to perform visual inspections and tests. This use case only considers the visuals examinations.</p> <p>It is assumed that the visual inspection will be performed periodically before the train is cleared for ATO or RO operations by authorised personnel.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • Operational category: All 	
Main goal	A visual inspection is required to prepare a train for departure, with the goal of ensuring that everything is clear for driving the train.	
Preconditions	<ul style="list-style-type: none"> • The train is inhibited to depart. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • The authorised personnel clears the train for ATO or RO operations after a visual examination.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • After the visual examination the train cannot be cleared for ATO or RO operations because the authorised personnel discovered a problem with the train.
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	Verify if Periodic Technical Inspections have been performed. Contact MBN if driving is restricted
	Step 2	Verify if there are any notifications or restrictions indicated. Contact driver helpdesk if driving is restricted.
	Step 3	Check if the train is ready for departure. Contact driver helpdesk if driving is restricted.
	Step 4	Check if all Safety Equipment is available. If any equipment is missing or dysfunctional, contact driver helpdesk.
	Step 5	Check if all relevant equipment is properly sealed. If a seal is broken, contact MBN.

	Step 6	Continue to perform system Functional Checks
Postcondition	The train can be cleared for ATO or RO operations.	
Use case notes	The operational process will continue with the use case ' <i>UC5.1-009 Conduct system and functional tests</i> '.	

Table 1: Use case “Conduct visual inspections and tests” description

1.9 UC5.1-009: CONDUCT SYSTEM AND FUNCTIONAL TESTS

Use case field	Description	
ID	UC5.1-009	
Use case name	Conduct system and functional tests	
Main actor	Either on board automation system (OAS) or the Remote driver (RD)	
Other actors	<ul style="list-style-type: none"> • Train • Driver helpdesk • Remote supervisor (RS) • Train display system (TDS) 	
Use case summary	As part of the protocol to prepare the train for departure, the driver needs to perform visual inspections and system functional tests. This use case only considers the system functional checks.	
Applicability	<ul style="list-style-type: none"> • Geographical: European and national • System level: On board automation system, RD • Operational category: Passenger 	
Main goal	The main goal is to successfully conduct all required functional tests on the train.	
Preconditions	A dedicated track is allocated to the train (either in shunting yard or at the platform) in order to perform its checks according to protocol. No alternative train traffic is possible on the allocated track. The train is "in service" mode.	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • The train passes the functional tests and can be cleared.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • The train fails one or more of the functional tests and is not cleared for departure.
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	The use case can be performed by the OAS system (starts at step 1.1) or the RD (starts at step 2.1).
	Step 1.1	Train checks if brake pipe pressure is 5 bar. If unsuccessful inform driver helpdesk.
	Step 1.2	Driver helpdesk provide Start of Mission data package to the train with train data, train nr, etc.).
	Step 1.3	Train performs ETCS self-test, checks proper functioning of the STM/ETCS and TDS/ETCS. If unsuccessful inform driver helpdesk.

	Step 1.4	Trains executes Warning & Caution light test. If unsuccessful inform driver helpdesk.
	Step 1.5	Train engages parking brake and executes brake test. If unsuccessful inform driver helpdesk.
	Step 1.6	Train executes dead man's switch test. If unsuccessful inform driver helpdesk.
	Step 1.7	Train executes brake loop test. If unsuccessful inform driver helpdesk.
	Step 1.8	Train executes traction loop test. If unsuccessful inform driver helpdesk.
	Step 1.9	Train loads Start of Mission data into the ETCS-OB and OAS-OB systems. Where possible verifies train data. If unsuccessful inform driver helpdesk.
	Step 1.10	Train executes Head, Marker and Tail lamp test. If unsuccessful inform driver helpdesk.
	Step 1.11	OAS enters driver id and train running number in GSM-R and verifies performance of the GSM-R.
	Step 1.12	(Use case successfully ends, step two is the same use case but performed by the remote driver.).
	Step 2.1	RD checks if brake pipe pressure is 5 bar on TDS. If unsuccessful inform RS.
	Step 2.2	Train performs ETCS self-test. If unsuccessful inform RD through TDS.
	Step 2.3	RD enters Start of Mission data and checks STM/ETCS and TDS/ETCS. If unsuccessful inform RS.
	Step 2.4	RD commands Warning & Caution light test by pushing the "lamp test" pushbutton. Train executes test. RD checks if warning and caution lights are properly relayed to the ROC TDS. If unsuccessful inform RS.
	Step 2.5	RD engages parking brake and commands brake test through the TDD. Train executes brake test. If unsuccessful inform RS.
	Step 2.6	RD commands dead man's switch test through the TDD. Train executes dead man's switch test. RD controls Train Direction Selector Lever accordingly and checks performance and brake pressure on manometer. If unsuccessful inform RS.

	Step 2.7	RD commands brake loop test. Train executes brake loop test. RD verifies performance and pressure on manometer. If unsuccessful inform RS.
	Step 2.8	RD commands traction loop test through the TDD. Train executes traction loop test. RD controls pantograph, dead man's, and Train Direction Selection Handle accordingly and check performance and pressure on manometer. If unsuccessful inform RS.
	Step 2.9	RD commands Train Head, Marker, and Tail lamp test. Train executes Head, Marker, and Tail lamp test. RD checks performance of lamp test using outside CAM video. If unsuccessful inform RS.
	Step 2.10	RD enters driver id and train nr in GSM-R and verifies performance of the GSM-R. If unsuccessful inform RS.
Postcondition	If step 1 is followed the OAS can start the trains mission. If step 2 is followed the RD can start the trains mission.	
Use case notes	N/A	

Table 1: Use case “Conduct system and functional tests” description

1.10 UC5.1-010: REPORT END OF SHIFT / ASSIGNMENT

Use case field	Description	
ID	UC5.1-010	
Use case name	Report end of shift/assignment	
Main actor	<ul style="list-style-type: none"> • Serviceable train • On-board Automation System (OAS) • Trackside Automation System (TAS) 	
Other actors	<ul style="list-style-type: none"> • Operations Manager • Fleet Automation System (FAS) 	
Use case summary	<p>This use case describes the operational scenario of “end of shift/assignment”.</p> <p>The train arrives at the final destination, reports its end of shift, and sets the train in the mode (or state) specified by the mission profile.</p> <p>The states of the train in parking includes:</p> <ul style="list-style-type: none"> • Train is parking with shutdown mode. • Train is parking with service retention mode (or stand-by mode). • Train in parking with energy saving mode. <p>Other train states are described in use case notes.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA3, GoA4 • Operational category: passenger, freight, urban, regional, mainline and inspection vehicles 	
Main goal	<ul style="list-style-type: none"> • When the train is at the end of movement, set the train in the required state. • Report the train states to the trackside. 	
Preconditions	<ul style="list-style-type: none"> • The On-board Automation System with subsystems like TCMS, ATO and ETCS are in operation. • The Mission Profile has defined which state the train should have after the end of shift/assignment, such as shutdown mode, service retention mode or energy saving mode. • In all these states the mobile communication is always on to guarantee the train can be waked up at any time. The state “Battery off” is therefore not a valid state for the train at the end of this use case. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: When the Serviceable train is at the end of movement, the train is automatically set in the correct state. The TAS is informed correctly of the mode of Serviceable train.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2: The Serviceable train is not set with correct state, for example, still in Service mode. • Outcome 3: The Trackside Automation System is not informed correctly of the state of Serviceable train.
Condition affecting termination outcome	Outcome 2 Outcome 3	<p>Explanations for unsuccessful outcomes:</p> <ul style="list-style-type: none"> • Mission Profile might not include the correct “end of shift/assignment” task,

		<ul style="list-style-type: none"> TAS not informed that the Serviceable train has reached the final stopping point and the train will execute “end of shift/assignment” task, The communication channel between TCMS and the Serviceable train has anomaly. <p>Post-conditions for unsuccessful outcomes</p> <ul style="list-style-type: none"> The “end of shift/assignment” task cannot be executed correctly. The train status is not correctly aligned in between train side and trackside. Further (operational) actions are necessary
Use case scenario	Step 1	OAS detects and confirms whether the Serviceable train has reached the final stopping point.
	Step 2	OAS informs TAS that the Serviceable train is at End of Journey (if Serviceable train has reached the final stopping point).
	Step 3	OAS sends “end of shift/assignment” message to TAS.
	Step 3.1	When Message could not be sent, or no reply arrives: go to Outcome 3
	Step 4	OAS sets the train in the state which is demanded by mission profile.
	Step 4.1	When The train state could not be set. Go to Outcome 2
	Step 5	The serviceable train is in the demanded state. The mobile communication sends heartbeats to FAS with the state.
Postcondition	<ul style="list-style-type: none"> When the train is at the end of movement, the train is set correctly in the required state. The trackside is correctly informed about train status. No matter in which the train is, the radio communication between the train and the RU trackside control centre is always on. Heartbeat between RU trackside (Fleet management) and mobile communication contains state of train. 	
Use case notes	<ul style="list-style-type: none"> This use case is related to two X2Rail-4 SRS Use cases: <ul style="list-style-type: none"> 13.2.5 Park autonomous train 13.2.6 Switch to retention of service This use case is related to X2Rail-4 SRS logical function: <ul style="list-style-type: none"> 12.3.11 Manage mission execution This use case is related to three X2Rail-4 ATO Operational scenarios: <ul style="list-style-type: none"> R11 Ending Journey R12 Ending Mission R13 Shutdown train This use case is related to the alignment of state machine of TCMS, which is still in progress in between X2Rail-4 ATO project (Figure 1) and X2R Connecta project (Figure 2). Especially the naming of the involved states has to be harmonized. 	

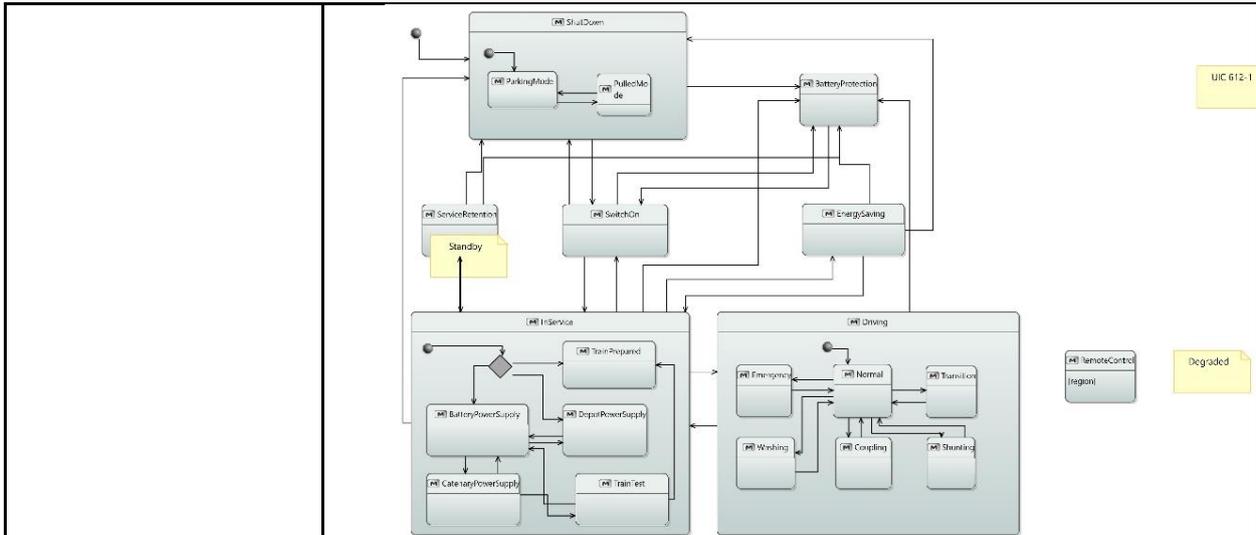


Figure 1 State Machine of TCMS in X2Rail-4 ATO Project

StateMachine: Train Mode CONNECTA

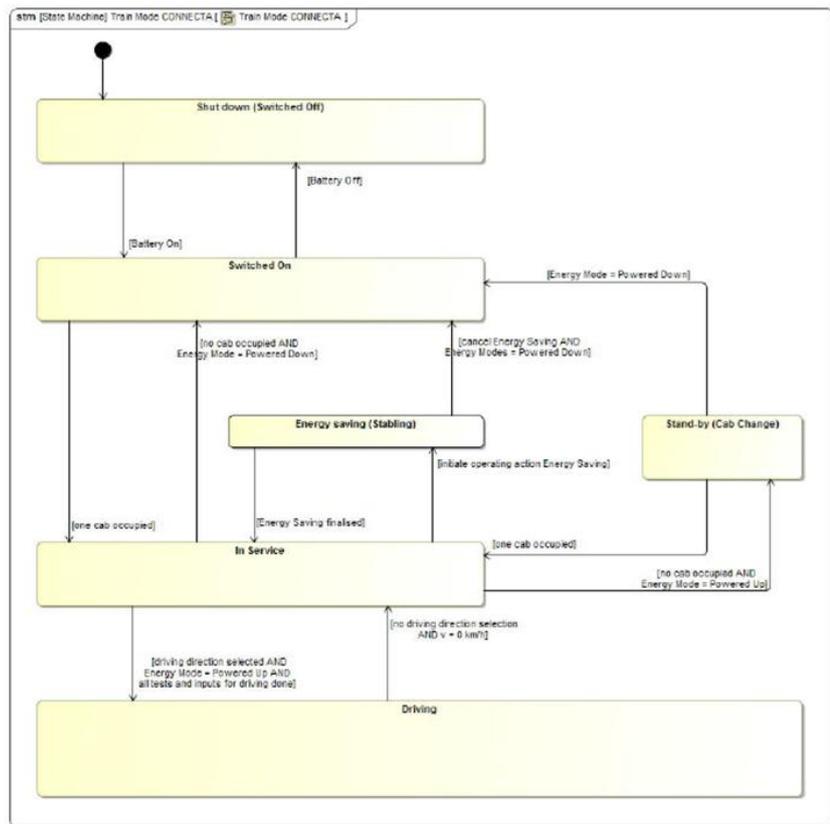


Figure 2 State Machine of TCMS in X2R Connecta Project

Table 1: Use case “Report end of shift assignment” description

1.11 UC5.1-011: STABLE A TRAIN UNIT – DETERMINE DETRAINMENT – AUTOMATIC

Use case field	Description	
ID	UC5.1-011	
Use case name	Stable a train unit – determine detrainment – automatic	
Main actor	On-board Automation System (OAS)	
Other actors	<ul style="list-style-type: none"> • Railway Undertaking Supervisor (RUS) • Railway undertaking Mobile Staff (RMS) • Trackside Automation System (TAS) 	
Use case summary	The train has to be cleared from passengers, before the train will be operated to a stabling position and is stabled.	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA4 • Operational category: passenger, urban, regional 	
Main goal	The train is removed from passenger service and stabled	
Preconditions	Train is about to arrive at terminal station.	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Train is stabled
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2: None
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	OAS: Inform passengers inside the train: “Terminal station reached, please leave the train at next station!” and outside the train with indication “do not enter!”.
	Step 2	TAS: Inform passengers at platform “Next train arrives and terminates here, do not enter!”
	Step 3	OAS: Release passenger doors, after train has stopped in terminal station at defined position.
	Step 4	OAS: Remove passenger door release after minimum dwell time is elapsed.
	Step 5	OAS: Wait for all passenger doors closed and locked and for RMS to disable one passenger door (if train has no automatic function to check train clear of passengers)
	Step 5.1	OAS: Wait for all passenger doors closed and locked (if train has automatic function to check train clear of passengers).

Step 5.1.1	OAS: Detect train clear of passengers (if train is clear of passengers). Continue Step 9.
Step 5.1.1.1	OAS: Report to RUS train not clear passengers (if still passengers on-board).
Step 5.1.1.2	RUS: Send RMS for investigation
Step 6	RMS: Disable one passenger door with a key and enter train to check train clear of passengers.
Step 7	RMS: Leave train after checking train clear of passengers and confirm this by enabling the passenger door again.
Step 8	OAS: Detect enabling of passenger doors and all passenger doors closed and locked.
Step 9	OAS: Drive train into stabling track.
Step 10	OAS: Stop train at defined position.
Step 11	OAS: Stable train.
Postcondition	Train is clear of passengers and stabled in stabling track.
Use case notes	The platforms may also be configured as stabling positions.

Table 1: Use case “Stable a train unit – determine detrainment – automatic” description

1.12 UC5.1-012: LEAVE TRAIN IN READY MODE

Use case field	Description	
ID	UC5.1-012	
Use case name	Leave train in ready mode	
Main actor	On board automation system (OAS)	
Other actors	N/A	
Use case summary	<p>Process to take train out of operating mode and into standby/ready mode. In standby/ready mode, the pantographs remain up and continue to provide power to the train.</p> <p>After 60 minutes of inactivity, the train automatically switches to sleep mode.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: ATO • Operational category: All 	
Main goal	successfully switch the train from operating mode to ready mode.	
Preconditions	The train must be in operating mode	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • The train switches to ready mode
	Unsuccessful outcomes	<ul style="list-style-type: none"> • The train does not switch to ready mode but stays in operating mode. • The train switches to another mode.
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	OAS: activate parking brake.
	Step 2	OAS: set traction/brake command to 0.
	Step 3	OAS: deactivate virtual cab.
	Step 4	OAS: set train to 'standby' mode. (UIC612-1).
	Step 5	OAS: set train to 'sleep' mode (if 60 mins of inactivity elapsed) - see 'UC5.1-013 Leave train in sleep mode'
Postcondition	ATO disengages from "operating" mode to "ready" mode.	
Use case notes	After putting the train in "ready" mode, the train can be set to "sleep" mode as described in use case 'UC5.1-013 Leave train in sleep mode'.	

Table 1: Use case "Leave train in ready mode" description

1.13 UC5.1-013: LEAVE TRAIN IN SLEEP MODE

Use case field	Description	
ID	UC5.1-013	
Use case name	Leave train in sleep mode	
Main actor	On board automation system (OAS) Railway undertaking supervisor (RUS)	
Other actors	N/A	
Use case summary	Set train to sleep mode after putting the train in ready mode. Sleep mode is a low-power state where the pantograph remains up, but certain accessories, such as the front and back train lights, are turned off.	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: OAS • Operational category: All 	
Main goal	To change the trains mode from “ready” to “sleep”.	
Preconditions	The train must be in “ready” mode (see use case ‘UC5.1-012 Leave train in ready mode’).	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • The train is successfully put in “sleep” mode.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • The train stays in “ready” mode. • The train changes to another mode.
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	RUS: check if train is in a correct stabling position to go to sleep mode.
	Step 2	OAS: activate parking brake.
	Step 3	OAS: set traction/brake command to 0.
	Step 4	OAS: deactivate virtual cab.
	Step 5	OAS: switch of front and rear lights.
	Step 6	OAS set train to 'sleep' mode.
Postcondition	The train is successfully set to “sleep” mode.	
Use case notes	N/A	

Table 1: Use case “Leave train in sleep mode” description

1.14 UC5.1-014: PERFORM MISSION

Use case field	Description	
ID	UC5.1-014	
Use case name	Perform mission	
Main actor	On-board Automation System (OAS)	
Other actors	<ul style="list-style-type: none"> • Trackside Automation System (TAS) • Fleet Automation System (FAS) • Railway Undertaking Supervisor (RUS) • Relevant Actor** 	
Use case summary	<p>This use case describes the process of carrying out a mission that has been previously defined. This is a general umbrella use case that describes the assignment of mission segments (journeys and perform mission movement as well as stopping segments and tasks to be conducted if train is stopped). The mission is considered complete when all the segments have been completed. If necessary (due to disruptions, emergencies etc.), a mission can be modified (if conditions for modifying the current mission are met) or aborted before all segments have been completed.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European Level • System level: System GoA3/4 • Operational category: passenger, urban, regional, mainline, freight 	
Main goal	<p>The main goal of this use case is to execute a mission and monitor the state of each mission segment. Mission segments can both refer to movement segments (journey) as well as segments of a mission (tasks) performed while the serviceable train is standing.</p>	
Preconditions	<ul style="list-style-type: none"> • Mission is defined (stop segments and move segments*). • Mission is ready for execution. • Current time \geq start time of first mission segment. • Mission is provided by RUS via FAS. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Mission is completed. • Outcome 2: RUS or FAS amend mission.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 3: Mission aborted.
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	OAS starts the mission.
	Step 2	OAS sets the execution state for one mission segment* when timing point is reached (or starts stopping mission segments if there is no conflict with the scheduled movement segments).
	Step 3	OAS or Relevant Actor** performs mission segment.

Step 4	OAS observes the mission segment execution state and registers that mission segment was completed.
Step 4.1	OAS observes the mission segment execution state and identifies that mission segment cannot be completed according to the specified limits.
Step 4.1.1	OAS observes the mission segment execution state and identifies that mission segment cannot be completed due to Non-Regular Situation.
Step 4.1.2	OAS reports operational event (deviation from mission) to TAS.
Step 4.1.3	TAS reports to FAS and RUS of affected train unit.
Step 4.1.4	FAS or RUS cancels mission.
Step 4.1.5	<ul style="list-style-type: none"> • Outcome 3: Mission aborted.
Step 4.2	OAS reports operational event (deviation from mission) to TAS.
Step 4.3	TAS reports operational event (deviation from mission) to RUS and FAS to update mission.
Step 4.4	<ul style="list-style-type: none"> • Outcome 2: RUS or FAS amend mission.
Step 5	OAS observes the mission execution state and registers that mission was completed.
Step 6	<ul style="list-style-type: none"> • Outcome 1: Mission is completed.
Postcondition	<ul style="list-style-type: none"> • Mission is completed successfully. • OAS is ready to receive new MP. • The train unit is stopped (velocity $V=0\text{kph}$).
Use case notes	<p>*Mission segment can refer to both move and stop segments.</p> <p>**Relevant actor here refers to the actor that a task was assigned to. This could be depending on the nature of the task maintenance personnel, service personnel or even a driver (if the mission segment involves for instance GoA1/2 segments).</p> <p>This use case describes the generic process for “perform mission”. Movement segments within a mission are covered by the use case “perform mission movement” and stop segments (tasks) are covered by individual use cases describing the tasks to be performed.</p> <p>A mission might be modified by the authorised stakeholders (train management, traffic management or even fleet manager, RUS, ECM) in sufficient time for the change to be safely adopted even by a moving train.</p>

Table 1: Use case “Perform Mission” description

1.15 UC5.1-015: SKIP STATION BY PASSENGER SERVICE

Use case field	Description	
ID	UC5.1-015	
Use case name	Skip station by passenger service	
Main actor	On-board Automation System (OAS)	
Other actors	<ul style="list-style-type: none"> • Railway Undertaking Supervisor (RUS) • Trackside Automation System (TAS) 	
Use case summary	The train is scheduled to skip a station without a stop, considering a limited speed for passing through the station.	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA4 • Operational category: passenger, urban, regional 	
Main goal	The train passes a station without stop and without passenger exchange.	
Preconditions	Train approaches to platform, where a skip requested in journey profile, e.g., for express trains.	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Train has passed station without stop.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2: Train has passed station with stop.
	Condition affecting termination outcome	Outcome 2
Use case scenario	Step 1	TAS: Inform travellers on platform about passing train, (if train is planned not to stop at this station).
	Step 1.1	OAS: Cancel station skip, (if there is an emergency situation on board of the train (e.g., smoke detected, passenger alarm activated)).
	Step 1.1.1	OAS: Inform passengers inside and outside about “unplanned stop and on-board incident!”.
	Step 1.1.2	TAS: Inform passengers at platform about “unplanned stop and not to enter train!”
	Step 1.1.3	OAS: Brake train and control speed to reach a precise station stop.
	Step 1.1.4	OAS: Apply holding brake, release, and open passenger doors.
	Step 1.1.4	OAS: Set departure inhibition.

	Step 1.1.5	RUS: Clarify emergency situation and reset departure inhibition. Continue with Step 3.
	Step 1.1.6	OAS: Inform passengers on-board about departure.
	Step 1.1.7	TAS: Inform passengers at platform about departure.
	Step 1.1.8	OAS: Dispatch train, i.e., revoke door release, wait all doors closed and depart.
	Step 2	OAS: Operate train through station until train has left station completely.
Postcondition	Train has passed station.	
Use case notes	N/A	

Table 1: Use case “Skip station by passenger service” description

1.16 UC5.1-016: IMPLEMENTING DISCRETIONAL STOPS BY REGIONAL SERVICES

Use case field	Description	
ID	UC5.1-016	
Use case name	Implementing discretionary stops by regional services	
Main actor	OAS (On-board Automation System)	
Other actors	<ul style="list-style-type: none"> • TAS (Trackside Automation System) • FMS (Fleet Management System) • Rolling Stock interfaces • Physical Train Unit 	
Use case summary	<p>This use case describes the need of passengers on-board or travellers on platform to request stops at some stations. Those stations are usually in less frequency request to stop. When no request on stops, serviceable train will skip those stops and continue the journey.</p> <p>In GoA1, this need is taken in charge by driver. Starting from GoA2, this need can be taken in charge automatically by systems.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: Train, remote control, GoA,2,3 & 4. • Operational categories: regional 	
Main goal	Passengers on-board or travellers on platform can request train stops at stations in advance.	
Preconditions	<ul style="list-style-type: none"> • The stations to be requested on stop is planned for the operation of specific lines. • The stations to be requested on stop is marked in On-board Multimedia and telematic Subsystem, Passenger Information System on platform, and any published timetable. • There are facilities on-board and on platform to request on stop. • The On-board Automation System fully operational. • The Trackside Automation System fully operational • On-board Multimedia and Telematic Subsystem (OMTS) is implemented in the train, and it provides various types of information to the passenger through visual, voice, or other media related to whether the train will stop or not. 	
Termination outcome	Successful outcomes	Mission updated with the new stop.
	Unsuccessful outcomes	Due to proximity to the next station, the stop request cannot be attended.
Condition affecting termination outcome	Outcome 2	
Use case scenario	Step 1	Train reduces speed to maximum speed to pass through stations when it reaches any station, with or without stop

	<p>request activated. This prevents that passengers push the stop request button too late to stop the train at the stop.</p> <p>On-board Multimedia and telematic Subsystem and the Passenger Information System on platform announce the stop on request to Passengers on-board and travellers on platform.</p>
Step 2	OAS (TCMS) aware of the new request and inform to the TAS or travellers on platform request on stop, the request is transmitted to both Trackside Automation System and Train Automation System.
Step 3.1	OAS (Train protection) register the position and current speed to OAS (localization).
Step 3.2	OAS (TP) asks for the position of the next station to OAS (REP).
Step 3.3	OAS (TP) sends to OAS(ADM) current speed and position of the train and position of the next station.
Step 4	OAS(ADM) calculates the breaking curve with the data provided and decides if it is possible or not to attend the request in a safe way for the train and for the passengers.
Step 5	If OAS (ADM) decides that it is possible to attend the stop request, it sends the new stop to the TMS.
Step 6	FMS will update the mission profile according to the UC 13.7.7 Update Mission.
Step 7	FMS will update the new MP to traffic management.
Postcondition	Train continues the new mission profile waiting for new stop requests.
Use case notes	<p>When there are no facilities on platform to request on stop, it is possible to use other perception systems to detect whether there are waiting travellers on the platform waiting for the stop of train. The solution is to be coordinated with railway operators.</p> <p>Related use cases:</p> <ul style="list-style-type: none"> • 13.7.7 Update Mission

Table 1: Use case “Implementing discretionary stops by regional services” description.

1.17 UC5.1-017: HANDLE MISSED BRAKING OR TARGET POINT

Use case field	Description	
ID	UC5.1-017	
Use case name	Handle missed braking or target point	
Main actor	On-board Automation System (OAS)	
Other actors	<ul style="list-style-type: none"> • Serviceable train • On-board Multimedia and telematic Subsystem (OMTS) • Trackside Automation System (TAS) • Incident Management System (IMS) • Fleet Management System (FMS) • Railway Undertaking Supervisor (RU Supervisor) • Operations Manager • Emergency Manager • Station Management • Platform Help Intercom • Fleet Manager 	
Use case summary	<p>When a train missed its braking point or target point, two abnormal scenarios might happen:</p> <ul style="list-style-type: none"> • Train undershoots a stopping point, • Train overshoots a stopping point. <p>When these abnormal scenarios happen, the On-board Automation System and Trackside Automation System should coordinate automatically to handle the stopping anomaly and help passengers with embark and disembark.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA3, GoA4 • Operational category: passenger, urban, regional, mainline 	
Main goal	<ul style="list-style-type: none"> • The safety of passengers is guaranteed, • Passengers embark and disembark is recovered when the train stopping anomaly is resolved. 	
Preconditions	<ul style="list-style-type: none"> • The On-board Automation System with subsystems like TCMS, ATO and ETCS fully operational • The Trackside Automation System fully operational 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: The stopping anomaly is detected automatically and adjusted automatically. Passengers embark and disembark is recovered as normal.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2: Train stopping anomaly cannot be adjusted.
Condition affecting termination outcome	Outcome 2	<p>Explanations for unsuccessful outcomes:</p> <ul style="list-style-type: none"> • Outcome 2: Trackside Automation System cannot generate an appropriate new Journey Profile to adjust the stopping anomaly. <p>Post-conditions for unsuccessful outcomes</p> <ul style="list-style-type: none"> • Outcome 2:
	Outcome 3	

		<ul style="list-style-type: none"> ○ The train overshoots and stops partially at station platform or totally out of station platform. ○ Passengers embark and disembark requires rescue. ○ Investigation of Trackside Automation System ○ Investigation of the communication channel between Trackside Automation System and On-board Automation System.
Use case scenario	Step 1	OAS monitors whether the Serviceable train applies the required braking force when passing by the braking point or target point.
	Step 2	When the Serviceable train missed the braking point or target point without implementing the required braking force, OAS adjusts the braking force to achieve the goal of stopping accuracy.
	Step 3	OAS monitors the stopping accuracy.
	Step 3.1	If the stopping accuracy is within the accepted gap, then train stops as normal and open doors for passengers embark and disembark.
	Step 3.2	If the stopping accuracy is out of the accepted gap, for example, <ul style="list-style-type: none"> • Train undershoots a Stopping point, • Or Train overshoots a Stopping point,
	Step 4	OAS should keep all doors closed and locked and inform this abnormal situation to passengers and to other systems (e.g. TAS, IMS and FMS).
	Step 4.1	OAS (OMTS) informs and instructs the on-board passengers the abnormal situation.
	Step 4.2	IMS evaluates whether rescue procedure is needed and coordinates the rescue procedure when needed with other resources, e.g., Station Manager, Emergency Manager, Platform Help Intercom, etc.
	Step 4.3	FMS and RU Supervisor evaluate if passengers need special help or if all passengers have access to door (when the train is partially stopped at the platform).
	Step 4.4	TAS decides whether to move forward or move reverse the train to the Stopping point.
	Step 5	OAS executes the commands from trackside of the jogging movement (backward or forward) to the correct stopping position.
	Step 6	Coordination between TAS and FMS, Operations Manager and RU Supervisor, to evaluates whether the delay needs to modify the traffic schedule.
Postcondition	<ul style="list-style-type: none"> • Train stopping anomaly is adjusted, • Passengers embark and disembark as normal, • Traffic schedule adjusted when needed. 	
Use case notes	<ul style="list-style-type: none"> • The degraded mode due to the failure of OAS or the failure of TAS is not described in this use case. • The ETCS failure case is out of scope. 	

Table 1: Use case “Handle missed braking or target point” description.

1.18 UC5.1-018: SET TRAIN INTO SERVICE

Use case field	Description	
ID	UC5.1-018	
Use case name	Set train into service	
Main actor	On board Automation System (OAS)	
Other actors	Trackside Automation System (TAS)	
Use case summary	The train starts from stabling track and approaches the scheduled platform, where it stops precisely. Passenger doors are prepared for opening and passengers are informed.	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA4 • Operational category: passenger, urban, regional, mainline 	
Main goal	The train stops precisely at the platform for passenger access.	
Preconditions	Train is prepared for passenger service (e.g. use-case WP5.1.ADIF-4) and waiting in stabling track.	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Train has stopped precisely at platform.
	Unsuccessful outcomes	N/A
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	TAS: Set route from stabling track into platform track and provide related information to OAS.
	Step 2	OAS: Set destination displays with destination information.
	Step 3	TAS: Inform passengers on the platforms about train set into service via passenger information system.
	Step 4	OAS: Drive train into platform track.
	Step 5	OAS: Stop train precisely, set holding brake and release passenger doors.
Postcondition	Train has stopped precisely at platform, has applied brakes and has released the passenger doors.	
Use case notes	N/A	

Table 1: Use case “Set train into service”

1.19 UC5.1-019: STOP AT PLATFORM FOR PASSENGER SERVICE

Use case field	Description	
ID	UC5.1-019	
Use case name	Stop at platform for passenger service	
Main actor	On board Automation System (OAS)	
Other actors	Trackside Automation System (TAS)	
Use case summary	The train approaches the scheduled passenger exchange position, where it stops precisely. Passenger doors are prepared for opening and passengers are informed in order to achieve an efficient passenger exchange.	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA3, GoA4 • Operational category: passenger, urban, regional, mainline 	
Main goal	The train stops precisely at a platform for a passenger exchange.	
Preconditions	Train approaches platform. Braking effort is set according to track conditions.	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Train has stopped precisely at platform.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2: Train skipped station.
Condition affecting termination outcome	Outcome 2	Overshoot of train.
	Step 1	OAS: Inform passengers on board about next stop and door side opening via passenger information system.
	Step 2	TAS: Inform passengers on the platforms about passenger exchange position via passenger information system.
	Step 3	OAS: Brake train according to set braking performance.
	Step 4	OAS: Stop train precisely (if within door opening authorization window).
	Step 4.1	OAS: Inform passengers on board about short stop (if train has stopped short).
	Step 4.1.1	OAS: Report to TAS about short stop.
	Step 4.1.2	TAS: Inform passengers on platform about short stop and that train will continue to move forward.

Step 4.1.3	OAS: Initiate forward jog train movement to passenger exchange position automatically. Continue with Step 6.
Step 4.2	OAS: Inform passengers on board about overshoot (if train has overshoot in a small extent and train is allowed to move in reverse direction).
Step 4.2.1	OAS: Report to TAS about overshoot.
Step 4.2.2	TAS: Inform passengers on platform about overshoot and train is about to move backwards.
Step 4.2.3	OAS: Initiate reverse jog train movement to passenger exchange position automatically. Continue with Step 6.
Step 4.3	OAS: Inform passengers on board about overshoot (if train has overshoot in a small extent and train is not allowed to move in reverse direction).
Step 4.3.1	OAS: Report to TAS about overshoot.
Step 4.3.2	TAS: Inform passengers on platform about overshoot.
Step 4.3.3	OAS: Inform passengers on board about partial door release and release only those doors, which are at the platform. Continue with Step 6.
Step 4.4	OAS: Inform passengers on board about station skip (if train has overshoot in large extent not sufficient for passenger exchange).
Step 4.4.1	OAS: Report to TAS about station skip.
Step 4.4.2	TAS: Inform passengers on platform about station skip.
Step 4.4.3	Go to Outcome 2.
Step 5	OAS: Apply holding brake and authorize passenger door opening at standstill.
Postcondition	Train has stopped precisely at platform, has applied brakes and has released the passenger doors.
Use case notes	N/A

Table 1: Use case “Stop at platform for passenger service” description

1.20 UC5.1-020: MANAGE PLATFORM SCREEN DOORS BY ATO

Use case field	Description	
ID	UC5.1-020	
Use case name	Manage Platform Screen Doors (PSD) by ATO	
Main actor	OAS (On Board Automation System)	
Other actors	<ul style="list-style-type: none"> Operational Execution Rolling Stock interfaces Remote Driver Physical Train Unit Physical Environment 	
Use case summary	<p>Certain rail lines, such as Madrid's commuter network, predominantly pass through tunnels and experience substantial demand during peak hours. On these lines, it should be feasible to install Platform Screen Doors (PSDs) to improve safety and streamline operations with Automatic Train Operation (ATO). Platform overcrowding is common, and despite the presence of a reliable safety system, the ATO may struggle to respond and stop the train promptly if a passenger accidentally falls from the platform onto the tracks.</p>	
Applicability	<ul style="list-style-type: none"> Geographical: European level System level: GoA 3&4. Operational categories: urban 	
Main goal	<p>PSD mitigate the risks associated with overcrowded platforms and minimize the difficulties of emergency braking in case of incidents, ultimately leading to a safer and more efficient rail service, avoiding non-permitted trespasses and accidental drops on the tracks.</p> <p>The main goal is to detect possible passengers blocked during platform screen doors are opening or closing. Also reacts if any passenger falls to the track.</p>	
Preconditions	<ul style="list-style-type: none"> OAS and TAS are fully operational. Platform screen doors active. Presence sensors checked and running in the platform screen doors. Presence sensors and door position sensors with the enough sensitivity to detect at least a non-correct closing operation. Sensors/cameras would be installed on the platforms or even in the doors. And in the event of a passenger drop, the system would send an alarm to all the trains in the area. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> Platform screen doors ensure a safe exchange of passengers without any passenger injuries.
	Unsuccessful outcomes	<ul style="list-style-type: none"> Any passenger falls to the track or become trapped in the platform screen doors during the passenger exchange.

Condition affecting termination outcome	Outcome 2	<ul style="list-style-type: none"> Presence sensors fail.
Use case scenario	Step 1	The train reduces speed when entering the station, and perception system (front cameras) monitors the platform to detect if no passenger has fallen onto the tracks or become trapped in the doors. *
	Step 2	If no passengers have fallen onto the tracks or become trapped in the doors go to step 3.
	Step 2.1	If cameras detect passengers into the track or trapped in the doors, OAS (ATP) sends an alarm to the remote driver and stops the train immediately.
	Step 2.2	Remote driver takes control of the train.
	Step 3	The train reaches the stopping point and checks its position to verify that it is correctly aligned with the doors.
	Step 4	OAS (TCMS) opens the doors and passenger exchange occurs.
	Step 5	After passenger exchange, OAS (TCMS) and TAS notice to the passengers that doors will close in the following seconds.
	Step 6	If sensors do not detect persons trespassing the doors, doors start to close and go to step 9.
	Step 7	If sensors detect any passenger or object trapped into the doors, TAS will open the doors and send an alarm to the OAS (ATP) to maintain the train stopped until the passenger or object has been released.
	Step 8	When TAS indicates that the passenger or object has been released go to step 6. If after a period of time (to be determined) the passenger or object hasn't been released, communicate to RU+ISM.
	Step 9	Doors are closed and platform screen doors and track are clear to continue mission.
	Step 10	Use case finished.
Postcondition		<ul style="list-style-type: none"> Passenger exchange successful and mission continues.
Use case notes	<p>The key point to the success of this UC is the sensitivity of the sensors in the platform screen doors.</p> <ul style="list-style-type: none"> In case of passengers fallen into the track, check use case 'UC5.2-019 React to Obstacle'. 	

Table 1: Use case “Manage Platform Screen Doors by ATO” description

1.21 UC5.1-021: PASS THROUGH VOLTAGE TRANSITION AREA OR PHASE SEPARATION AREA

Use case field	Description	
ID	UC5.1-021	
Use case name	Pass through voltage transition area or phase separation area	
Main actor	Train	
Other actors	N/A	
Use case summary	General passing of a stretch of track which requires a change in catenary voltage or phase lock.	
Applicability	<ul style="list-style-type: none"> Geographical: European level System level: Catenary / Overhead lines Operational category: All 	
Main goal	The goal is to ensure that the train can successfully pass a stretch of track where there is a voltage transition applicable.	
Preconditions	Approaching a passage of track with a different voltage.	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> Successfully continue the journey after changing the voltage.
	Unsuccessful outcomes	<ul style="list-style-type: none"> The voltage is not/ not correctly changed, and the train is possibly damaged.
	Condition affecting termination outcome	Outcome 2
Use case scenario	Step 1	The train is approaching transition-track with enough inertia to coast until the next overhead line or third rail.
	Step 1.1	The train is passing the sign pantograph down.
	Step 1.1.1	<p>A point in rear of the end of the overhead line present at scenario entry, early enough to allow the sequence to develop before reaching the end of this overhead line. I.e., this point may vary according to the train speed.</p> <p>The end of the overhead line defined as a new powerless section or a Power Voltage Change (ETCS S-026 v3.6.4, S-126 v0.1.1) with qualified as 'Line not fitted with any traction system.</p>
	Step 1.1.2	Open main switch.
	Step 1.1.3	Train lowers pantograph/ switches main switch to off.

	Step 2	if applicable: changing voltage, Train System switches current selection.
	Step 3	The end of the powerless section in step 1.1. (ETCS S-026 v3.6.4, S-126 v0.1.1) or a Power Voltage Change (S-126 v0.1.1).
	Step 3.1	Train system pantograph/ main switch automatically.
	Step 3.1.1	continue driving.
Postcondition	The train continues its journey with a different voltage.	
Use case notes	N/A	

Table 1: Use case “Pass through voltage transition area of phase separation area” description

1.22 UC5.1-022: PASS A BRIDGE WITHOUT OVERHEAD LINE

Use case field	Description	
ID	UC5.1-022	
Use case name	Pass a bridge without overhead line	
Main actor	Train driver	
Other actors	Train systems	
Use case summary	No high voltage is present during the passage of a bridge.	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • Operational category: All 	
Main goal	The train successfully passes a bridge without an overhead line	
Preconditions	<ul style="list-style-type: none"> • The train driver is seated in the active driver cab. • The train is in operate mode. • High voltage is present. • No traction blocking and traction can be given. • Train Set is Mono-courant (no passage of VCO). 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • The train successfully passes the bridge. • The train successfully regains traction power.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • The train does not make it over the bridge.
	Condition affecting termination outcome	Outcome 2 N/A
Use case scenario	Step 1	Driver knows a bridge with no overhead line is on immediate route, train Driver sees SIGN "SA RS 306A" (pantograph low in ATB) or DMI message under ERTMS.
	Step 2	Driver stops giving traction and puts Master Controller in 'Coast'.
	Step 3	<ul style="list-style-type: none"> • No HV available. • All Systems needed for graceful powering up traction and other systems after returning overhead voltage stays powered. • No traction is possible due to no HV from overhead line.
	Step 4	After passing sign "SA RS307a" (pantograph low in ATB) with number of total coaches or DMI message under ERTMS all the coaches have passed the bridge and the pantographs are under powered high voltage overhead line.
	Step 5	The Train Driver can give traction again with no further actions required (e.g., Closing MCB or raising Pantograph

		or resetting systems). If HV systems need starting up again, this shall not have negative influence on errors.
Postcondition	<ul style="list-style-type: none"> • The train is in operate mode. • High voltage is present. • No traction blocking and traction can be given. • No passage related errors present. 	
Use case notes	N/A	

Table 1: Use case “Pass a bridge without overhead line” description

1.23 UC5.1-023: MANAGE DAILY INTERIOR CLEANING, END OF LINE

Use case field	Description	
ID	UC5.1-023	
Use case name	Manage daily interior cleaning, end of line	
Main actor	Train preparation staff (TPS)	
Other actors	Train set	
Use case summary	The interior of the train set is cleaned. The train set is ready to continue passenger service.	
Applicability	<ul style="list-style-type: none"> Geographical: European level Operational category: passenger, urban, regional and mainline 	
Main goal	Cleaning of the Train Set at end of line; possibly multiple times per day.	
Preconditions	<ul style="list-style-type: none"> The Train Set is in operation mode 'ready'. Only cleaning agents as prescribed by NS are allowed to use. The Train Set is stabling along the platform, passengers have left the Train Set. Passengers on the platform are advised not to board the Train Set while it is being cleaned. The team-lead of the cleaning crew has the DOM CM 99 Z key (The key to open the cabin). Cleaning staff has a rectangular key (The key to open the doors of the passenger compartment). Note: There is no specific operational mode set during this cleaning. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> The train is successfully cleaned and ready to continue for passenger service.
	Unsuccessful outcomes	<ul style="list-style-type: none"> The cleaning staff was unable to successfully clean the train set.
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	<p>The train set is stabling at a platform, during operational services, mainly at the end of a line.</p> <p>The TPS operates autonomously at a station and knows the available time slots for cleaning. The Train Set remains in the timetable schedule.</p>
	Step 3	<p>The TPS cleans the driver's cab:</p> <ul style="list-style-type: none"> Litter is removed from the driver's desk and then wiped. Waste bin is emptied.
	Step 4	Clean the passenger area.

	The passenger area is dry cleaned (litter removed from luggage racks, tables and seats, waste bins emptied).
Step 5	Clean the toilet, refill the supplies: <ul style="list-style-type: none"> • The floor is wet cleaned. • Vacuum toilet module is cleaned. • Supplies (soap, toilet paper, towels if applicable for older rolling stock) are refilled.
Step 6	Clean the entry vestibule. The process of cleaning the entry vestibule is similar the to process of cleaning the passenger area.
Step 7	Finish the cleaning, leave the Train and store the tools and take care of personal hygiene measures.
Step 8	The TPS finishes the administration of the workorder. In case the cleaning is not fully ready, but the Train Set has to continue passenger services, the cleaning is aborted to stick to the timetable, the train broadcasts the end of the cleaning session to all TPS in the train via OMTS.
Postcondition	<ul style="list-style-type: none"> • The Train Set is cleaned, and passengers may board the Train Set
Use case notes	<p>When the Train Set needs a cleaning that is unforeseen, the Train Set will be taken out of passenger service and will be directed to a Location with cleaning facilities.</p> <p>At that location dedicated cleaning takes place. In such a case the team-lead of the cleaning crew will communicate with process manager of NS.</p> <p>There could be made use of a register and unregister of the TPS, this could be used to broadcast enhanced warning to TPS. A process amendment may be that the train is spared until Un registration of the TPS team leader. For this 'demonstrator level' use case, the passenger service should not be delayed. Once the train is supposed to leave, it will leave.</p>

Table 1: Use case “Manage daily interior cleaning, end of line” description

1.24 UC5.1-024: PREPARE THE TRAIN SET FOR MAINTENANCE - PERFORM VARIOUS MAINTENANCE TASKS IN PARALLEL

Use case field	Description	
ID	UC5.1-024	
Use case name	Prepare the train set for maintenance - Perform various maintenance tasks in parallel	
Main actor	Vehicle maintenance worker	
Other actors	<ul style="list-style-type: none"> • Train set • Maintenance depot • OB-automation system 	
Use case summary	To optimize downtimes due to maintenance, and therefore aims to execute maintenance tasks in parallel without compromising safe working. The train set needs to enable safe working on individual electrical systems while other electrical systems may be under electric power.	
Applicability	<ul style="list-style-type: none"> • Geographical: European • Operational category: All 	
Main goal	To perform several maintenance tasks in parallel in a safe manner to optimize downtimes.	
Preconditions	The Train Set is on the track in front of the maintenance depot, in operating mode 'operate' and is ready to be driven to a pit track in the maintenance depot.	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Several maintenance tasks have successfully been performed in parallel.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • The tasks couldn't be performed in parallel. • A safety issue occurred due to performing the tasks in parallel.
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	OB-automation system drives the Train Set to a pit track in the maintenance depot.
	Step 2	<p>The maintenance worker performs checks for which the Train Set need to be powered from the overhead catenary line while the Train Set is in operation mode 'operate'.</p> <p>Such as:</p> <ul style="list-style-type: none"> • Check sifa • Check master controller • Check JRU (functionality) • check diagnostic messages / failure codes

Step 3	Disconnect the Train Set from the overhead catenary power supply by lowering the pantograph and prevent re-connection. See maintenance task description. This step is performed in accordance with local regulations and procedures. An example could be the switch to switch off the catenary power is secured with a personal physical lock.
Step 4	<p>The maintenance worker disconnects power supply of the overhead catenary of the related pit track in the Maintenance Depot. The maintenance worker grounds the overhead catenary of the related pit track and secures it against re-powering up. Check the pit track:</p> <ul style="list-style-type: none"> • Warning lights show 'green'. <p>Depending on the facilities in the Maintenance Depot the way to prevent to power-up the overhead catenary line is different.</p> <p>E.g.,</p> <ul style="list-style-type: none"> • While the track is grounded a key is mounted in a central block. • Maintenance worker lock-out and tag-out the power supply of the track in a digital system. As long as one person is present it is not possible to power up the track, an example could be a personal physical lock. <p><i>(After step 4 has been finished, step 5.1 and 5.2 may be started in parallel.)</i></p>
Step 5.1	Maintenance worker performs maintenance tasks on exterior mounted systems that do not require electric power. If applicable, the individual system will be locked-out and tagged-out during maintenance.
Step 5.2	Maintenance worker connects the Train Set to the electric workshop power supply.
Step 6	<i>When step and 5.2 has been finished, step 7 until 9 may be started, simultaneously with step 5.1.</i>
Step 7	<i>maintenance task in the interior of the Train Set that do not require electric power, except lighting</i>
Step 8	<p>Maintenance task at interior mounted systems that do (partly) require electric power.</p> <p>E.g.: maintenance of a doorstep that includes:</p> <ul style="list-style-type: none"> • Function test, check for noises. • Cleaning and lubricating tasks (locked-out and tagged-out) Individual systems need to be tagged out and

		locked out in accordance with local health and safety procedures.
	Step 9	Maintenance task at exterior mounted systems that do (partly) require electric power. E.g.: function test of a system (under power).
Postcondition	N/A	
Use case notes	N/A	

Table 1: Use case “Prepare the train set for maintenance - Perform various maintenance tasks in parallel” description

1.25 UC5.1-025: DRIVE TRAIN THROUGH WASHING STATION

Use case field	Description	
ID	UC5.1-025	
Use case name	Drive train through washing station	
Main actor	On-board automation system	
Other actors	Train	
Use case summary	Driving a train through a washing station	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: Washing station, Shunting yard • Operational category: passenger, freight, urban, regional, mainline and inspection vehicles (some restrictions may apply) 	
Main goal	To successfully drive a train through a washing station to be cleaned.	
Preconditions	Every washing station and train type has its own local procedures and regulations, therefore only a generic current situation description can be made. The train is in the correct “mode” according to the local washing station procedure.	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • The train is successfully cleaned in the washing station and is ready to continue its journey
	Unsuccessful outcomes	<ul style="list-style-type: none"> • The train was not able to get cleaned and is not ready to continue its journey
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	Approaches washing station and drive according to local procedures. The local procedures vary for virtually every washing station, one of the variables is the speed in which the train is allowed to approach the washing station.
	Step 2	Drive through washing installation according local and train specific procedures.
	Step 3	On-board automation system continues according to normal procedure if train has fully exited washing station.
Postcondition	The train can continue its journey after being cleaned.	
Use case notes	<p>Every washing station requires different procedures, and these currently cannot be exhaustively identified across all partners. This use case therefore is a generic use cases, to highlight the overall process, where specific operational differences can later be added to by R2DATO partners.</p> <p>Finally, driving through the washing station is a process that might be difficult to automatize, in the washing station it regularly occurs that washers</p>	

	get stuck or other problems arise. In these cases, the emergency buttons have to be pressed.
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Table 1: Use case “Drive train through washing station” description

1.26 UC5.1-026: DRIVE THROUGH ANTI-ICING STATION

Use case field	Description	
ID	UC5.1-026	
Use case name	Drive train through anti-icing station	
Main actor	On board automation system (ATO)	
Other actors	Train set	
Use case summary	Driving a train to and through an anti-icing station in accordance with "handboek machinist" (operators handbook).	
Applicability	<ul style="list-style-type: none"> • Geographical: The Netherlands • System level: Anti-icing station • Operational category: passenger, freight, urban, regional, mainline and inspection vehicles 	
Main goal	The main goal is to successfully dispose the ice that has built up on the train and continue the train's journey.	
Preconditions	If signal 370 (sign: anti-icing in order) is on, the anti-ice is active, but the train will not necessarily undergo the treatment. If the speed signal (5) is on, then the train will receive the treatment.	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • The ice is successfully removed from the train and the train can continue its journey.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • The ice was not successfully removed from the train.
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	ATO approaches anti-ice station.
	Step 2*	Drive according to local procedures and reduce speed to 5 km/h if speed signal is on (this signal means the train will undergo anti-ice treatment).
	Step 3	The brakes are sprayed with an anti-icing liquid.
	Step 4	Drive through anti-ice with max 5 km/h until the train has fully passed the anti-icing station, then the train can accelerate according to applicable local rules.
	Step 5	Apply full or emergency brake, depending on train type. Brake from 30 km/h till 0 km/h to distribute the anti-icing liquid evenly on the wheel.
	Step 6	The train can now continue its journey.

Postcondition	N/A
Use case notes	*Step 2 is necessary to distribute the anti-icing liquid evenly on the whole wheel. Anti-icing stations are a Dutch solution to removing ice from the brakes and the wheels.

Table 1: Use case “Drive train through anti-icing station” description

**1.27 UC5.1-027: OPERATE FULL AUTONOMOUS TRAINS AT LOW SPEED \leq 30KM/H
IN STABLING YARD OR SHUNTING AREA EQUIPPED OR NOT WITH ETCS
INFRASTRUCTURE**

Use case field	Description	
ID	UC5.1-027	
Use case name	Operate Full autonomous trains at low speed \leq 30km/h in stabling yard or shunting Area equipped or not with ETCS infrastructure	
Main actor	On-board Automation System (OAS)	
Other actors	Trackside Automation System (TAS) Fleet Management System (FMS)	
Use case summary	Full autonomous operations of trains at low speed $<$ 30km/h in stabling yard or shunting area equipped or not with ETCS infrastructure based on X2Rail SRS. The vehicle moves from current position to demanded position and stops there.	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA3, GoA4 • Operational category: passenger, freight, urban, regional, mainline and inspection vehicles: <ul style="list-style-type: none"> ◦ with the restriction of $V_{max}=30\text{km/h}$ and limited to shunting areas and stabling yards 	
Main goal	Autonomous train operation in low speed in special areas without commercial traffic.	
Preconditions	<ul style="list-style-type: none"> • Train powered on. • The On-board Automation System with subsystems like TCMS, ATO and ETCS fully operational. • The Trackside Automation System fully operational. • Fleet Automation System fully operational. <p>In the case where the shunting area is not equipped with ETCS, the following preconditions are necessary:</p> <ul style="list-style-type: none"> • Cab selection is realised without ETCS. • OAS can secure the path instead of ETCS. For this task OAS may use perception and/or information from interlocking. <p>Then this use case works for ETCS and non-ETCS areas.</p>	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Vehicle moved without accident to new position in stabling yard or shunting area.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2: Vehicle did not move due to various reasons. • Outcome 3: Vehicle moves to wrong position. • Outcome 4: Movement stopped because of obstacle.
	Outcome 2	<p>A number of reasons can lead to Outcome 2:</p> <ul style="list-style-type: none"> • No JP/SP could be provided.

Condition affecting termination outcome		<ul style="list-style-type: none"> • Real Starting position different from JP starting position. • Rolling stock failure (brakes, traction, catenary). • Obstacle in front of vehicle. • APM/PER failure. • ADM failure. • In ETCS-areas: no MA. • In non-ETCS areas: no driving permission. • ETCS failure. • Blocking engagement conditions like open doors. • Derailment. • Train separation. <p>Postconditions: OAS informs TAS and FMS about unmovable vehicle. FMS sends staff to solve the problem.</p>
	Outcome 3	<p>A number of reasons can lead to Outcome 3:</p> <ul style="list-style-type: none"> • Inconsistent JP/SP • Wrong position of switches • Rolling stock failure (brakes, traction, catenary, TCMS, etc.) • APM/PER failure • ADM failure • In ETCS-areas: no MA • In non-ETCS areas: no driving permission • ETCS failure <p>Postconditions: OAS informs TAS and FMS about the failure. FMS sends staff to resolve the problem.</p>
	Outcome 4	<p>A non-disappearing Obstacle on the ego track prevents reaching the desired position.</p> <p>Postcondition: OAS reports obstacle to TAS. FMS sends staff to solve the issue.</p>
Use case scenario	Step 1	<p>Use case “13.3 autonomous train preparation” from SRS or use case ‘UC5.1-018 Set train into service’ from WP5.</p> <p>The train is prepared and has mission, journey- and segment profiles. The train is localised.</p>
	Step 1.1	If this fails, go to Outcome 2.
	Step 2	OAS reports “train ready for shunting” to TAS.
	Step 3	OAS activates the shunting mode.
	Step 4	OAS applies a speed limit of 30 km/h for shunting.
	Step 5	TAS sends JP to OAS.
	Step 6	TAS sets the route (set switches and set signals or ETCS-MA).

	Step 7	OAS receives MA or detects the image of the signal(s) and drives the train to the desired location.
	Step 7.1	At any time during the shunting operation: if an obstacle is present in the ego-track: OAS stops the train in rear of the obstacle.
	Step 7.1.1	If the obstacle persists, go to Outcome 4.
	Step 7.1.2	If the obstacle vanishes, OAS continues driving and reports delay to TAS. Continue to Step 8
	Step 7.2	If the desired destination could not be reached, go to Outcome 3.
	Step 8	OAS stops the train in desired destination.
Postcondition	Vehicle stopped and applied parking brake. If the JP is not finished yet, OAS will continue to execute the JP. If the JP is finished, continue with execution of mission profile.	
Use case notes	<ul style="list-style-type: none"> • This use case is related to X2Rail-4 ATO Operational scenario: <ul style="list-style-type: none"> ○ R30 Drive inside depot / stabling or maintenance facility (work in progress). • This use case is related to X2Rail-4 SRS Use cases: <ul style="list-style-type: none"> ○ 13.3 autonomous train preparation. ○ 13.4 move autonomous train. • This use case is related to WP5.1 use case: <ul style="list-style-type: none"> ○ <i>UC5.1-018, "Set train into service"</i>. • Recommend discussion: <ul style="list-style-type: none"> ○ Is $V_{max} = 30$ ok for every situation or are there RU which use 40 km/h as maximal shunting velocity? • Specific actions (if any) to be carried out per a mission profile when the train reaches the desired location are out of scope of the present use case (for example coupling/uncoupling). 	

Table 1: Use case “Operate Full autonomous trains at low speed ≤ 30 km/h in stabling yard or shunting Area equipped or not with ETCS infrastructure” description

1.28 UC5.1-028: PREPARE TRAIN FOR CLEANING DURING SHUNTING

Use case field	Description		
ID	UC5.1-028		
Use case name	Prepare train for cleaning during shunting		
Main actor	Remote Driver (RD)		
Other actors	<ul style="list-style-type: none"> • Train dispatcher • Train preparation staff (TPS) • ADM • TCMS 		
Use case summary	Move the train to a shunting position and prepare the train for cleaning by setting it in the correct operating mode “cleaning”.		
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level (for which system(s) is the UC applicable?) • Operational category: passenger, urban, regional, mainline 		
Main goal	To successfully place the train in the correct position on the shunting yard and set the train in operating mode “cleaning” so the cleaning staff can clean the train.		
Preconditions	<ul style="list-style-type: none"> • Train has permission to move in the shunting yard. • Shunting is being carried out within a specified time & space slot. • A shunting operator is present who can change infrastructure elements such as switches, if necessary. 		
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • The train is in the correct position and operating mode to get cleaned by the cleaning staff. 	
	Unsuccessful outcomes	<ul style="list-style-type: none"> • The train is not in the correct position. • The train is not in the correct operating mode. 	
	Outcome 2	A visual mistake is made by the remote operator.	
Condition affecting termination outcome	Outcome 2	A visual mistake is made by the remote operator.	
	Use case scenario	Step 1	The RD drives the train to the correct position on the shunting yard in accordance with use case ‘ <i>UC5.1-027 Full autonomous operations of trains at low speed 30km/h in stabling yard or shunting Area equipped or not with ETCS infrastructure</i> ’.
		Step 1.1	The RD stops the train at this position.
	Step 1.1.1	The train is set to the correct operating mode “cleaning” by the RD.	
Postcondition	The train successfully arrives at the correct position and the operating mode is set to cleaning. The TPS can now start the cleaning process.		

Use case notes	This use case is related to use case ' <i>UC5.1-027 Full autonomous operations of trains at low speed 30km/h in stabling yard or shunting Area equipped or not with ETCS infrastructure</i> '.
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Table 1: Use case “Prepare train for cleaning during shunting” description

1.29 UC5.1-029: PERFORM TRANSITION FROM CBG TO NCBG

Use case field	Description	
ID	UC5.1-029	
Use case name	Perform transition from CBG to NCBG	
Main actor	Remote driver (RD)	
Other actors	<ul style="list-style-type: none"> • Train dispatcher • ETCS TS • TCMS • On-board automation system • Signaller 	
Use case summary	<p>A CBG (centrally controlled area) consists of infrastructure (signals, switches, etc.) which are controlled from one central point. The train signaller is responsible for the safety of the rail traffic and maintains an overview of the trains in the area. The majority of the Dutch rail network is CBG.</p> <p>A NCBG (non-centrally controlled area), by contrast, consists of infrastructure which is controlled locally. On a NCBG, the train dispatcher cannot guarantee safety, thus this lies solely with the train driver. The train dispatcher and the driver must make agreements on which movements will be performed and when. A handful of shunting yards are designated as NCBG.</p> <p>This use case describes the CBG-to-NCBG transition, and only covers transition between CBG-NCBG (drive up to S-board and receive permission to enter NCBG).</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: The Netherlands • System level: ATO, TCMS, ETCS TS • Operational category: All 	
Main goal	The main goal is to ensure a safe transition from CBG-NCBG.	
Preconditions	<ul style="list-style-type: none"> • The train is driving normally on a known route in a CBG towards an NCBG. • Remote operator has or will receive a shunting assignment. • Driving in the NCBG is only possible by a remote operator (no ATO). 	
Termination outcome	Successful outcomes	The transition is successful.
	Unsuccessful outcomes	The transition is unsuccessful.
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	Train dispatcher designates area as NCBG.

	Step 2	ETCS Extend MA to on-sight MA (OSMA).
	Step 3	TCMS Receive OSMA notification.
	Step 4	TCMS and OB-automation system Inform RS and propose SH mode. Respect EoA and stop if necessary.
	Step 5	RD Take control of train.
	Step 6	RD Confirm SH mode and disengage OB-automation system.
	Step 7	TCMS Switch to SH mode.
	Step 8	RD Request permission to enter NCBG.
	Step 9	Command train to carry out shunting activities.
Postcondition	OB-automation system cannot be activated, and the RD has control over the train. This use case is focused on the Netherlands, but the generic idea could be applicable to other countries as well.	
Use case notes	N/A	

Table 1: Use case “Perform transition from CBG to NCBG” description

1.30 UC5.1-030: PERFORM TRANSITION FROM NCBG TO CBG

Use case field	Description	
ID	UC5.1-030	
Use case name	Perform transition from NCBG to CBG	
Main actor	Remote driver (RD)	
Other actors	Train dispatcher, Infra, TCMS, OB-automation system	
Use case summary	Transition from RD control inside a NCBG (non-centrally controlled area) to either ATO control or continued RD control in a CBG (centrally controlled area).	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: ATO, TCMS, Infra • Operational category: All 	
Main goal	To transition successfully from a non-centrally controlled area to a centrally controlled area and continue the journey.	
Preconditions	<ul style="list-style-type: none"> • Shunting assignment is complete. • No further instructions have been given for continued movement. • Train is at a standstill at the NCBG-CBG the zone of transition/handover. • RD is in control of the train. • - OB-automation system cannot be engaged within the NCBG area. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • The transition is successful and OB-automation system /RD is in control of the train.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • The transition is unsuccessful, and the train cannot continue its journey.
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	OB-automation system/RD informs NCBG train dispatcher of end of shunting assignment
	Step 2	<p>Is it possible for OB-automation system to be engaged while still in the NCBG?</p> <p>If yes, continue to step 3</p> <p>If no, continue to step 2.1</p>
	Step 2.1	Drive to boundary NCBG-CBG; check switch positions, track clear, observe signals.
	Step 3	Has an MA been received?

		If no, request MA by contacting the train dispatcher.
	Step 4	Inform RD about MA via DMI.
	Step 5	Confirm MA and engage OB-automation system mode. Train should request confirmation that it is ok to engage OB-automation system mode.
	Step 6	Switch to OB-automation system mode.
	Step 7	Drive in accordance with MA.
Postcondition	The Train can continue the journey under control of OB-automation system or the RD.	
Use case notes	N/A	

Table 1: Use case “Perform transition from NCBG to CBG” description

1.31 UC5.1-031: BORDER CROSSING

Use case field	Description	
ID	UC5.1-031	
Use case name	Border crossing	
Main actor	On board automation system	
Other actors	N/A	
Use case summary	General passing of a geographical border; either to Belgium or Germany.	
Applicability	<ul style="list-style-type: none"> • Geographical: the Netherlands, Belgium, Germany • System level: On board automation system • Operational category: passenger, freight, mainline and inspection vehicles 	
Main goal	To pass the border to either Belgium or Germany successful.	
Preconditions	N/A	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • The border is crossed successfully.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • The border couldn't be crossed due to a problem.
	Outcome 2	N/A
Condition affecting termination outcome		
Use case scenario	Step 1	Approaching Border.
	Step 1.1	If applicable: voltage transition/phase-separation procedure is initiated by the train (use case 'UC5.1-021 Pass through voltage transition area or phase separation area').
	Step 1.1.1	If applicable: ATP-switches to new system (STM/ETCS) depending on direction.
	Step 2	Change GSMR-Network at border.
	Step 3	Continue driving.
Postcondition	The train continues its journey in a different country (If the time zone is changed, the HMI may change local times on all systems impacted).	
Use case notes	This UC is focussed on the Netherlands, Belgium and Germany but might be applicable to other countries as well.	

Table 1: Use case “Border crossing” description

1.32 UC5.1-032: INSPECTION TRAIN: ELABORATE MISSION AND JOURNEY PROFILES INCLUDING INSPECTION ACTIVITIES

Use case field	Description
ID	UC5.1-032
Use case name	Inspection Train: Elaborate mission and journey profiles including inspection activities
Main actor	IM (Infrastructure Manager)
Other actors	<ul style="list-style-type: none"> • Fleet manager • Fleet Management System (FMS) • Railway Undertaking Supervisor (RUS) • On-board Automation System (OAS) • Trackside Automation System (TAS) • Traffic Management System (TMS)
Use case summary	This use case describes the actions to add to the previous X2Rail-4 use case “13.2.1 <i>Elaborate mission and journey profiles</i> ”. It includes the Mission Profile (MP), information about the inspection activity, i.e., precise positioning of the starting and finishing points of the area to inspect and the type of inspection (depending on the nature of the inspection, different devices on board have to be deployed to inspect the infrastructure or the environment).
Applicability	<ul style="list-style-type: none"> • Geographical European level • System level (for which system(s) is the UC applicable?) • Operational category: inspection vehicles
Main goal	<p>Special trains, inspection vehicles for example among others, are intended to be employed as regular train in the near future in terms of traffic. These special trains should have a Mission Profile in the same way of the other trains, and they could be intercalated between passengers or freight trains.</p> <p>Taking advantage of this functionality additional parameters of special missions could be added to the Mission Profile to automate missions that nowadays are completed manually.</p> <p>Missions related to inspection or maintenance activities could be an example of this, where special parameters could be added to the Mission Profile in order to automate the process of inspection itself. In this way, starting and finishing points could be added to the Journey Profile (JP) as regular stops and/or to the Mission profile. In both points, sensors or inspection devices will be deployed and retracted. Information about the position of both points will be added to the JP and/or MP. Besides, information about the inspection activities could also be included in the MP, including information about the inspection area, events that should be analysed, the environment, potentially dangerous situations, etc.</p>

	This UC is an extended version of the UC 13.2.1 <i>Elaborate mission and journey profiles</i> from the X2Rail-4 project.	
Preconditions	A maintenance mission (inspection activity) is scheduled, and a Journey Profile must be created.	
Termination outcome	Successful outcomes	MP is created with the data about the inspection activity.
	Unsuccessful outcomes	MP cannot be created with the data about the inspection mission.
	Outcome 2	IM cannot provide information to Train management and RUS about inspection activity.
Condition affecting termination outcome		
Use case scenario	Step 1	IM defines a new inspection mission and sends the details to RUS.
	Step 1.1	RUS defines a new mission considering that it is a special mission.
	Step 1.2	IM and RUS request a mission to FMS. FMS determines the mission data.
	Step 1.3	TMS defines stops including starting and finishing points and potential speed reduction along the inspection area according to the inspection activities.
	Step 1.4	FMS (Train management) validates the mission.
	Step 2	RUS (with the mission defined in step 1) ask for Fleet manager to allocate vehicle depending on the inspection activities to be done.
	Step 2.1	Fleet manager with information about the type of inspection (sensors and monitoring systems) assigns a maintenance vehicle to the mission.
	Step 2.2	In concordance with Train Data and IM, information about train parameters is loaded in the Repository (REP).
	Step 3	OAS (REP) requests MP to TAS.
	Step 3.1	TAS determines MP data and requests to TMS stopping and passing points (including the ones about the inspection area). The mission data including information about the type of inspection.
	Step 3.2	TAS verifies and transmits the MP to OAS (REP).
	Step 4	OAS (REP) sends ATO ID to TAS.
	Step 4.1	FMS (Train management) registers train unit ID.

	Step 4.2	Digital Map provides an infrastructure database and sends MP to OAS (REP).
Postcondition	JP, MP and SP including data about the inspection mission ready.	
Use case notes	Directly related with the following X2Rail-4 use case: 13.2.1 Elaborate mission and journey profiles.	

Table 1: Use case “Inspection Train: Elaborate mission and journey profiles including inspection activities” description.

1.33 UC5.1-033: INSPECTION TRAIN: ARRIVING AT THE STARTING POINT OF THE AREA TO BE INSPECTED

Use case field	Description	
ID	UC5.1-033	
Use case name	Inspection Train: Arriving at the starting point of the area to be inspected	
Main actor	On-board Automation System (OAS)	
Other actors	<ul style="list-style-type: none"> • Traffic Management System (TMS) • Remote Driver 	
Use case summary	This use case describes the actions to be completed once the inspection vehicle has arrived at the starting point of the area of inspection, before starting the inspection activities.	
Applicability	<ul style="list-style-type: none"> • Geographical European level • System level (for which system(s) is the UC applicable?) • Operational category: inspection vehicles 	
Main goal	<p>Missions of inspection vehicles are divided in two parts, firstly the inspection vehicle should arrive/return to/from the inspection area in an autonomous way (Goa3/4), Once the vehicle has arrived at the starting point of the inspection area determined by the Journey Profile (JP) it should stop and deploy the devices to analyse the infrastructure or the environment. Once the train finishes the inspection activities and it reaches the end of the inspection area other UC describes the process to retract the inspection devices.</p> <p>Depending on the devices needed, mechanical parts could be deployed such as frames to support devices, robotic arms with cameras or sensors, etc. After the deployment some checks must be completed to assure the correct state and communication with the devices.</p>	
Preconditions	<ul style="list-style-type: none"> • Mission Profile (MP) includes information about maintenance activities, mainly: <ul style="list-style-type: none"> ○ Precise positioning of the area to be inspected and stopping points of the starting and finishing points. ○ Information about the inspection devices (sensors, etc..) to deploy/retract once the train reaches the starting/finishing point of the area to be inspected. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Train stops at the starting point of the area of interest. • Train deploys the sensors correctly. • Train checks the state of the inspection devices. • Train ready to start the inspection activities.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Train cannot stop at the starting point of the inspection area. • Train cannot deploy inspection devices. • Train deploys inspection devices but cannot check the functionality.

Condition affecting termination outcome	Outcome 2	<ul style="list-style-type: none"> MP does not include information about the inspection area. MP does not include information about devices to deploy/retract.
Use case scenario	Step 1	Train stops at the starting point of the inspection area according to the MP.
	Step 2	OAS (TCMS) selects the devices to deploy.
	Step 2.1	OAS (TCMS) power on the selected device.
	Step 2.2	OAS (TCMS) checks power supply for the device.
	Step 2.3	OAS (TCMS) sends command to deploy device.
	Step 2.4	OAS (TCMS) checks deployment of the device.
	Step 2.5	OAS (TCMS) checks possible sensor/device failures.
	Step 2.6	Repeat step 2 for each device.
	Step 3	OAS (TCMS) checks the storage media.
	Step 4	OAS (TCMS) informs to remote driver and OAS (APM) that it is ready to start the inspection activity.
	Step 5	Use case successfully ends.
Postcondition	Train ready to start the inspection activities.	
Use case notes	<p>Directly related to the following UCs:</p> <ul style="list-style-type: none"> UC5.1-032 Inspection vehicles: Elaborate mission and journey profiles including inspection activities. UC5.1-034 Inspection Train: Finishing the inspection, retract devices, check data and prepare to return. X2Rail-4 UC 13.4.7 Determine Stopping point for a freight or passenger train. TAURO PST1 Testing of RAD/LID/CAM-sensors availability from. 	

Table 1: Use case “Inspection Train: Arriving at the starting point of the area to be inspected” description

1.34 UC5.1-034: INSPECTION TRAIN: FINISHING THE INSPECTION, RETRACT DEVICES, CHECK DATA AND PREPARE TO RETURN

Use case field	Description	
ID	UC5.1-034	
Use case name	Inspection Train: Finishing the inspection, retract devices, check data, and prepare to return	
Main actor	On-board Automation System (OAS)	
Other actors	<ul style="list-style-type: none"> • Traffic Management System (TMS) • Remote Driver 	
Use case summary	This use case describes the actions to complete once the inspection vehicle has arrived at the finishing point of the area of inspection, after successfully completing the inspection activities.	
Applicability	<ul style="list-style-type: none"> • Geographical European level. • System level (for which system(s) is the UC applicable?) GoA 3&4. • Operational category: inspection vehicles. 	
Main goal	<p>Missions of inspection vehicles are divided in two parts, firstly the inspection vehicle should arrive/return to/from the inspection area in an autonomous way (Goa3/4), Once the vehicle has completed the inspection area determined by the Mission Profile (MP) it should stop and retract the devices employed to analyse the infrastructure or the environment.</p> <p>Depending on the devices needed, mechanical parts should be retracted such as frames to support devices, robotic arms with cameras or sensors, etc.</p>	
Preconditions	<ul style="list-style-type: none"> • MP includes information about maintenance activities, mainly: <ul style="list-style-type: none"> ○ Precise positioning of the area to be inspected and stopping points of the starting and finishing points. ○ Information about the inspection devices (sensors, etc..) to deploy/retract once the train reaches the starting/finishing point of the area to be inspected. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Train completes the inspection activities successfully. • Train retracts the sensors correctly. • Train checks the integrity of data stored. • Train is ready to return from the inspection area.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Train cannot complete the inspection activity. • Train cannot retract inspection devices. • Train cannot confirm data integrity in the storing media.
	Outcome 2	<ul style="list-style-type: none"> • MP does not include information about the inspection area. • MP does not include information about devices to deploy/retract.
Condition affecting termination outcome		
Use case scenario	Step 1	Train completes the inspection activity and stops at the finishing point of the inspection area according to the MP.

Step 2	OAS (TCMS) selects the devices to retract.
Step 2.1	OAS (TCMS) sends command to retract the device.
Step 2.2	OAS (TCMS) checks device retract.
Step 2.3	AOS (TCMS) power off the device.
Step 2.4	Repeat step 2 for each device.
Step 3	OAS (TCMS) checks the integrity of the data in the storage media dedicated to inspection activities.
Step 4	OAS (TCMS) informs to remote driver and OAS (APM) that it is ready to return from the inspection area.
Step 5	Use case successfully ends.
Postcondition	Train ready to return from the inspection area.
Use case notes	<p>Directly related to the following UCs:</p> <ul style="list-style-type: none"> • UC5.1-032 Inspection vehicles: Elaborate mission and journey profiles including inspection activities. • UC5.1-034 Inspection Train: Finishing the inspection, retract devices, check data and prepare to return. • X2Rail-4 UC 13.4.7 Determine Stopping point for a freight or passenger train. • TAURO PST1 Testing of RAD/LID/CAM-sensors availability from.

Table 1: Use case “Inspection Train: Finishing the inspection, retract devices, check data and prepare to return” description.

1.35 UC5.1-035: PERFORM AUTOMATIC TRAIN SHUNTING AND "SPECIAL" MOVEMENTS: NON-SCHEDULED STOP, STOP AT NEXT EMERGENCY STOP AREA

Use case field	Description						
ID	UC5.1-035						
Use case name	Perform automatic train shunting and "special" movements: Non-scheduled stop, stop at next emergency stop area						
Main actor	Remote Driver						
Other actors	<ul style="list-style-type: none"> • Physical Train Unit • Passenger • Rail Undertaking Supervisor (RUS) • Trackside Automation System (TAS) • On-board Automation System (OAS) • Fleet Management System (FMS) 						
Use case summary	This use case aims to illustrate the actions to be taken in case a train needs to perform a non-scheduled stop as a result of a degraded situation or emergency. For example, it could be needed to stop at a station after a passenger triggers an alarm handle.						
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA3/4 • Operational categories: Regional 						
Main goal	Perform a non-scheduled stop as a result of a degraded situation or emergency.						
Preconditions	<ul style="list-style-type: none"> • The train must operate at GoA3/4 and run on a line equipped with GoA3/4. • The train is performing a mission with certain stopping and rescue points predefined. • TCMS is fully operative. • Remote driver is ready and available to take control of the train. In certain emergency situations, several trains could need remote operation at the same time. • PER is fully operative. 						
Termination outcome	<table border="1"> <thead> <tr> <th>Successful outcomes</th> <th></th> </tr> </thead> <tbody> <tr> <td></td> <td> <ol style="list-style-type: none"> 1. GoA3 operation: if the train is in SR mode and a degraded situation occurs, the train attendant will take care of the situation until a remote train driver is available to drive the train. 2. GoA4 operation: if the train is in FS mode and an emergency stop occurs, the APM then should perform the required manoeuvre. <p><i>Note:</i></p> <ul style="list-style-type: none"> - Staff Responsible (SR) - Full Supervision (FS) </td> </tr> <tr> <th>Unsuccessful outcomes</th> <td> <ul style="list-style-type: none"> • Communication failure → The Remote Driver could not control the train. </td> </tr> </tbody> </table>	Successful outcomes			<ol style="list-style-type: none"> 1. GoA3 operation: if the train is in SR mode and a degraded situation occurs, the train attendant will take care of the situation until a remote train driver is available to drive the train. 2. GoA4 operation: if the train is in FS mode and an emergency stop occurs, the APM then should perform the required manoeuvre. <p><i>Note:</i></p> <ul style="list-style-type: none"> - Staff Responsible (SR) - Full Supervision (FS) 	Unsuccessful outcomes	<ul style="list-style-type: none"> • Communication failure → The Remote Driver could not control the train.
	Successful outcomes						
	<ol style="list-style-type: none"> 1. GoA3 operation: if the train is in SR mode and a degraded situation occurs, the train attendant will take care of the situation until a remote train driver is available to drive the train. 2. GoA4 operation: if the train is in FS mode and an emergency stop occurs, the APM then should perform the required manoeuvre. <p><i>Note:</i></p> <ul style="list-style-type: none"> - Staff Responsible (SR) - Full Supervision (FS) 						
Unsuccessful outcomes	<ul style="list-style-type: none"> • Communication failure → The Remote Driver could not control the train. 						

		<ul style="list-style-type: none"> OAS has a fault that prevents APM/REP functions from being performed (Failure state) or the APM/REP loss of communication with the system.
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	<p><i>[Remote driver takes control - SR mode] - Outcome 1</i></p> <p>Operational Scenario 13.7.2 <i>Unexpected Stop</i>, until “Define reflexive reaction depending on incident”. The outcome should be “Notify trackside (train anomaly, track anomaly)”.</p>
	Step 1.1	<p>Operational Scenario <i>UC.5.4.Mastership11: Give control to remote operator.x.DrivingAtTractionChainLevel.</i></p> <p>When degraded situations occur during a train running in GoA3/4 mode, OAS must request hand-over to the Remote driver and/or train attendant (GoA4 or GoA3) then, when the hand-over is confirmed and mastership changes to the remote-control mode, the remote driver must drive the train.</p>
	Step 1.2	<p>Operational Scenario 13.12.1 <i>Remote Driving.</i></p> <p>RUS must be able to activate a TCMS remote control mode to bypass the GoA3/4 commands and accept the commands of a remote driver.</p>
	Step 1.3	<p>Operational Scenario 13.7.6 <i>Move the train locally</i> until the Safe Stopping Point is reached.</p>
	Step 1.4	<p>Leave the train in sleep mode, as stated in use case ‘<i>UC5.1-013 Leave train in sleep mode</i>’.</p>
	Step 2	<p><i>[OAS(APM) performs the manoeuvre – FS mode] - Outcome 2</i></p> <p>When an emergency stop (a passenger triggers an alarm handle) occurs during a train running in GoA3/4 mode, then the OAS(APM) should analyse and evaluate reactions and safety procedures.</p>
	Step 2.1	<p>Operational Scenario 13.7.2 <i>Unexpected Stop</i>, until “Define evaluated reaction depending on incident”. The outcome should be a “Passenger alarm”.</p>
	Step 2.2	<ul style="list-style-type: none"> Operational Scenario 13.9.14 <i>Use of Passenger Alarm in station.</i> Operational Scenario 13.9.15 <i>Use of Passenger Alarm when train is starting (train still along platform).</i> X2Rail-4 Operational Scenario 13.9.16 <i>Use of Passenger Alarm during train run.</i>

		<ul style="list-style-type: none"> Task 5.1 Operational Scenario <i>UC5.1-054 Emergency on train - in station.</i>
	Step 2.3	X2Rail-4 Operational Scenario <i>13.7.12 Stop at next station or rescue point.</i>
	Step 2.4	Leave the train in sleep mode, as stated in use case ' <i>UC5.1-013 Leave train in sleep mode</i> '.
Postcondition	<p><i>Outcome 1:</i></p> <ul style="list-style-type: none"> The train stopped at a Safe Stopping Point where a driver must be available to continue in a lower GoA level or where maintenance is possible without affecting traffic operation. <p><i>Outcome 2:</i></p> <ul style="list-style-type: none"> Train stopped at a Safe Stopping Point. Restart the procedure after an unexpected stop. According to X2Rail-4 Operational Scenario <i>13.7.4 Restart after unexpected stop.</i> 	
Use case notes	<p>Related use cases:</p> <p>X2Rail-4 Deliverable D5.1 WP5 GoA3/4 Specification (SRS 0.3.0):</p> <ul style="list-style-type: none"> 13.7.2 Unexpected stop. 13.7.4 Restart after unexpected stop. 13.7.6 Move the train locally. 13.7.12 Stop at next station or rescue point. 13.9.14 Use of Passenger Alarm in station. 13.9.15 Use of Passenger Alarm when train is starting (train still along platform). 13.9.16 Use of Passenger Alarm during train run. 13.12.1 Remote Driving. <p>R2DATO – WP5:</p> <ul style="list-style-type: none"> UC5.1-013 Leave train in sleep mode' UC5.1-054 Emergency on train - in station Task 5.4 use case UC.5.4.Mastership11: Give control to remote operator.x.DrivingAtTractionChainLevel 	

Table 1: Use case “Perform automatic train shunting and "special" movements: Non-scheduled stop, stop at next emergency stop area” description.

1.36 UC5.1-036: MANAGE TRAIN – TRAIN COLLISION

Use case field	Description	
ID	UC5.1-036	
Use case name	Manage Train – Train collision	
Main actor	On board Automation System (OAS), Operations Manager (OM)	
Other actors	<ul style="list-style-type: none"> • Trackside Automation System (TAS) • Railway Undertaking Supervisor (RU) • Energy Manager (EM) 	
Use case summary	This use case describes the steps to be performed after a train-train collision if this is still possible due to the damage.	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA3/4 • Operational category: passenger, urban, regional 	
Main goal	After the collision, the trackside will be informed that passengers shall be rescued.	
Preconditions	A train-train collision has occurred.	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: After the collision, OAS is still able to report the collision and rescue can be organized.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 1: The train and the OAS is so damaged that a communication with TAS is not possible.
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	OAS immobilizes the train. This step happens in parallel to next step and step 6.
	Step 2	OAS reports the collision with another train to TAS/OM. OM takes next steps 3-4 happen in parallel.
	Step 3	OM orders an emergency stop for all the trains in the area.
	Step 4	OM takes corresponding actions in case of emergency according to the country.
	Step 5	TAS defines an area around the crash location.
	Step 6	TAS updates the JP/MP of other trains in order to stop before the accident area or avoid the accident area depending on train's journey.
	Step 7	OM requests EM to shut down the catenary power.

		See X2Rail-4 v0.1, SRS 0.3, §13.7.9 Ask catenary power shutdown, and §13.8.5 about derailment.
	Step 8	OAS keeps the door opening inhibited.
	Step 9	OAS informs passengers.
	Step 10	IM organizes rescue.
Postcondition	The incident location is secured, and the passengers are rescued.	
Use case notes	<p>Step 1-4 are done in parallel.</p> <p>The following X2Rail-4 references have been used:</p> <ul style="list-style-type: none"> • 13.7.3 Set local alarm • 13.8.5 Derailment or presumption of derailment • 13.7.9 Ask catenary power shutdown 	

Table 1: Use case “Manage Train – Train collision” description

1.37 UC5.1-037: HANDLE HOT WHEEL DUE TO BRAKE FAILURE - BRAKE FAILURE DETECTED THROUGH HOT BOXES DETECTOR: CONTINUE TO NEXT STATION

Use case field	Description	
ID	UC5.1-037	
Use case name	Handle hot wheel due to brake failure - Brake failure detected through hot boxes detector: continue to next station	
Main actor	PTU – Physical Train Unit (monitor of wheelset temperature)	
Other actors	<ul style="list-style-type: none"> • IM – Infrastructure Manager • IPM – Incident Prevention Module • ISM – Incident Solving Manager • OAS – On-board Automation System • TMS – Traffic Management System 	
Use case summary	<p>A hot wheel due to brake failure is detected through on-board hot boxes detector. The vehicle shall continue to the next station (or intervention station) and stops.</p> <p>Possible country-specific management: intervention stations are predefined stations where a vehicle that raised an alarm will be stopped and checked.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA3, GoA4 • Operational category: passenger, freight, urban, regional, mainline and inspection vehicles 	
Main goal	Prevent damages due to a reached temperature limit, indicative of the condition of a bearing, above which damage will occur to the bearing and/or its functionality, with the potential to lead to a hazardous event.	
Preconditions	<ul style="list-style-type: none"> • Train is running. • Brake failure detected through on-board hot boxes detectors. • Failure reaction shall be "continue to next intervention station". 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Speed reduction according to local prescription. • Outcome 2: Stop at the next intervention station. • Outcome 3: Information to passengers. <p>The UC is successful if the three outcomes are satisfied.</p>
	Unsuccessful outcomes	<p>Outcome 4: Anomaly not detected by APM. Outcome 5: No update of Journey Profile (JP) via REP. Outcome 6: New JP doesn't fulfil local requirements. Outcome 7: No speed reduction (if was required). Outcome 8: Non-scheduled stop before the inter. Station. Outcome 9: Intervention station missed. Outcome 10: No action planned by IPM nor ISM at station. Outcome 11: No information about the stop to passengers.</p>

Use case field	Description	
Condition affecting termination outcome	Outcomes	<p>Explanation for unsuccessful outcomes</p> <ul style="list-style-type: none"> • Failure of monitoring components. • Communication issue between components. • No update of JP due to communication issue. • No update of JP due to wrong reaction of IM/TMS. • No co-operative shorten MA proposed by APM. • New JP/MA doesn't fulfil the requirements. • ADM doesn't operate according to new JP / MA. • Train attendant not informed in GoA 3. • No information through OMTS in GoA 3. • Intervention request (vehicle check) not actuated. <p>Post-conditions for unsuccessful outcomes</p> <ul style="list-style-type: none"> • Stop the vehicle. • Inform Operations Manager. • Act according Operations Manager indication. • Bring the vehicle to suited station for check (manually, with JP or rescue the vehicle). • Possibly evacuate the passengers. • Investigation of the issue.
Use case scenario	Step 1	TCMS detects brake failure through hot boxes detector.
	Step 1.1	<i>Communication issue (outcome 4: anomaly not detected by APM).</i>
	Step 2	APM generates hot box alarm.
	Step 2.1	<i>Communication issue (outcome 5: no update of JP).</i>
	Step 3	APM communicates with REP.
	Step 4	APM co-operative shorts the MA.
	Step 4.1	<i>Wrong reaction of IM/TMS (outcome 5: no update of JP).</i>
	Step 4.2	<i>No co-operative shorten MA proposed by APM (outcome 5: no update of JP).</i>
	Step 5	New JP is provided
	Step 5.1	<i>Wrong reaction of IM/TMS/APM (outcome 6: new JP doesn't fulfil local requirements).</i>
	Step 6	Train acts according to the new JP (speed reduction, etc.)
	Step 6.1	<i>ADM doesn't operate according to new JP / MA (outcome 7: no speed reduction (if was required)).</i>
	Step 6.2	<i>ADM doesn't operate according to new JP / MA (outcome 8: non-scheduled stop before the intervention station)</i>

Use case field	Description	
	Step 6.3	<i>ADM doesn't operate according to new JP / MA (outcome 9: intervention station missed).</i>
	Step 7	Train stops in intervention station.
	Step 8	Train attendant (GoA 3) is informed about the situation.
	Step 8.1	<i>Train attendant not informed (outcome 11: no information about the stop to passengers).</i>
	Step 8bis	Information is provided through OMTS (GoA 3/4).
	Step 8bis.1	<i>No information provided by OMTS (outcome 11: no information about the stop to passengers).</i>
	Step 9	IPM-ISM (or entities according to local prescriptions) actuates an intervention request (check of the vehicle).
	Step 9.1	<i>Request not actuated (outcome 10: no action planned by IPM nor ISM at station).</i>
	Step 10	Train is temporarily suspended and TMS updated.
Postcondition	<ul style="list-style-type: none"> • Train and hot wheels / boxes are checked. • If no damage (test case) --> perform brake test. • If damages (test case) --> train suspended. • TMS updated. • New JP is delivered if continuation of journey allowed. 	
Use case notes	<p>Local specific requirements to be checked and implemented (see for example I-30064 and I-50099 in Switzerland).</p> <p>In accordance with IM, test different reactions depending on:</p> <ul style="list-style-type: none"> • With/without speed reduction. • Impact of distance before the intervention station on shortened MA. • Hot box alarm triggered short before intervention station (stop in station only possible with emergency brake). Applying EB can lead to hazard and shall be avoided. • Hot box alarm triggered just after intervention station with significant distance before the next suitable station (for example > 50 km). 	

Table 1: Use case “Handle hot wheel due to brake failure - Brake failure detected through hot boxes detector: continue to next station” description

1.38 UC5.1-038: HANDLE HOT WHEEL DUE TO BRAKE FAILURE - BRAKE FAILURE DETECTED THROUGH HOT BOXES DETECTOR: STOP IMMEDIATELY

Use case field	Description				
ID	UC5.1-038				
Use case name	Handle hot wheel due to brake failure - Brake failure detected through hot boxes detector: stop immediately				
Main actor	PTU – Physical Train Unit (monitor of wheelset temperature)				
Other actors	<ul style="list-style-type: none"> • IM – Infrastructure Manager • IPM – Incident Prevention Module • ISM – Incident Solving Manager • OAS – On-board Automation System • TMS – Traffic Management System 				
Use case summary	A hot wheel due to brake failure is detected through on-board hot boxes detector. The vehicle shall stop immediately, meant as soon as possible.				
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA3, GoA4 • Operational category: passenger, freight, urban, regional, mainline and inspection vehicles 				
Main goal	Prevent damages due to a reached temperature limit, indicative of the condition of a bearing, above which damage will occur to the bearing and/or its functionality, with the potential to lead to a hazardous event.				
Preconditions	<ul style="list-style-type: none"> • Train is running. • Brake failure detected through on-board hot boxes detectors. • Failure reaction shall be stop immediately, meant as soon as possible. 				
Termination outcome	<table border="1"> <thead> <tr> <th>Successful outcomes</th> <th></th> </tr> </thead> <tbody> <tr> <td></td> <td> Outcome 1: Service brake is triggered. Outcome 2: Stop in a suited area. Outcome 3: Information to passengers. Outcome 4: Appropriate reaction of IM / TMS. The UC is successful if the four outcomes are satisfied. </td> </tr> </tbody> </table>	Successful outcomes			Outcome 1: Service brake is triggered. Outcome 2: Stop in a suited area. Outcome 3: Information to passengers. Outcome 4: Appropriate reaction of IM / TMS. The UC is successful if the four outcomes are satisfied.
Successful outcomes					
	Outcome 1: Service brake is triggered. Outcome 2: Stop in a suited area. Outcome 3: Information to passengers. Outcome 4: Appropriate reaction of IM / TMS. The UC is successful if the four outcomes are satisfied.				

Use case field	Description	
	Unsuccessful outcomes	<p>Outcome 5: Anomaly not detected by APM. Outcome 6: No Service brake triggered. Outcome 7: Service brake triggered although not allowed by local specific requirements. Outcome 8: Emergency brake triggered instead SB. Outcome 9: Vehicle stops in a ETCS non-stopping area. Outcome 10: Vehicle stops in an unsuited place like a tunnel or a bridge (if not designed/prescribed for it). Outcome 11: No information about the stop to passengers. Outcome 12: No reactions of TMS (vehicle immobilised on a track). Outcome 13: No alarm/action actuated by IPM nor ISM. Outcome 14: Any issue in standstill like open the doors.</p>
Condition affecting termination outcome	Outcomes	<p>Explanation for unsuccessful outcomes:</p> <ul style="list-style-type: none"> • Failure of monitoring components. • Communication issue between components. • Issues with APM: <ul style="list-style-type: none"> ○ No brake requested by APM. ○ Brake requested despite not suited area. ○ Wrong brake (EB) requested by APM. • No brake triggered/applied by Train Protection. • Issue with HW component like brake valve. • Train attendant not informed in GoA 3. • No information through OMTS in GoA 3/4. • Intervention request not actuated by ISM. <p>Post-conditions for unsuccessful outcomes:</p> <ul style="list-style-type: none"> • Stop the vehicle. • Inform Operations Manager. • Act according Operations Manager indication. • Bring the vehicle to suited station (manually, with JP or rescue the vehicle) for a check. • Possibly evacuate the passengers. • Investigation of the issue.
Use case scenario	Step 1	TCMS detects brake failure through hot boxes detector.
	Step 1.1	<i>Communication issue (outcome 5: anomaly not detected by APM).</i>
	Step 2	APM generates hot box alarm.
	Step 2.1	<i>Communication issue (outcome 6: no service brake triggered).</i>
	Step 3	APM communicates with REP.
	Step 4	APM requests a service brake.
	Step 4.1	<i>No brake requested by APM (outcome 6: no service brake triggered).</i>

Use case field	Description	
	Step 4.2	<i>Brake requested despite not suited area (outcome 7: service brake triggered although not allowed by local specific requirements).</i>
	Step 4.3	<i>Brake requested despite not suited area (outcome 9: Vehicle stops in a ETCS non-stopping area).</i>
	Step 4.4	<i>Brake requested despite not suited area (outcome 10: Vehicle stops in an unsuited place like tunnel or bridge).</i>
	Step 4.5	<i>Wrong brake (EB) requested by APM (outcome 8: Emergency brake triggered instead).</i>
	Step 5	Train Protection (TP) applies service brake.
	Step 5.1	<i>HW- or SW-issue (outcome 6: no service brake triggered).</i>
	Step 6	Train is at standstill.
	Step 7	Train attendant (GoA 3) is informed about the situation.
	Step 7.1	<i>Train attendant not informed (outcome 11: no information about the stop to passengers).</i>
	Step 7bis	Information is provided through OMTS (GoA 3/4).
	Step 7bis.1	<i>No information provided by OMTS (outcome 11: no information about the stop to passengers).</i>
	Step 8	Appropriate reaction of IM / TMS.
	Step 8.1	<i>No actions took, although vehicle blocked on the track (outcome 12: No reactions of TMS).</i>
	Step 9	IPM-ISM (or entities according to local prescriptions) actuates an intervention request (check of the vehicle).
	Step 9.1	<i>Request not actuated (outcome 13: no alarm/action actuated by IPM nor ISM).</i>
	Step 10	Train is temporarily suspended and TMS updated.
Postcondition	<ul style="list-style-type: none"> • Train and hot wheels / boxes are checked. • If no damage (test case) --> perform brake test. • If damages (test case) --> train suspended. • TMS updated. • New JP is delivered if continuation of journey allowed. • Rescue and evacuation are planned if needed. 	

Use case field	Description
<p>Use case notes</p>	<p>Local specific requirements to be checked and implemented (see for example I-30064 and I-50099 in Switzerland).</p> <p>In accordance with IM, test different reactions depending on:</p> <ul style="list-style-type: none"> • with/without speed reduction (if stop not immediately allowed). • impact of distance before an unsuited area for stop and the trigger of the service brake. • hot box alarm triggered in an unsuited area. • hot box alarm triggered in station while the train is running. • Possibility to light delay the service brake if the train is approaching a station (goal would be to stop in the station, easier to manage the passenger)? • Maximal speed by delaying the service brake (due to non-stopping area for example). <p>Evaluate the elapsed time before intervention team will be at the vehicle.</p> <p>The management of passengers in a GoA4 train unit while has stopped en-route needs to be covered in a separate use case.</p>

Table 1: Use case “Handle hot wheel due to brake failure - Brake failure detected through hot boxes detector: stop immediately” description

1.39 UC5.1-039: HANDLE HOT WHEEL DUE TO BRAKE FAILURE - BRAKE FAILURE THROUGH TRAIN OUTSIDE OBSERVATION: STOP IMMEDIATELY

Use case field	Description	
ID	UC5.1-039	
Use case name	Handle hot wheel due to brake failure - Brake failure through train outside observation: stop immediately	
Main actor	TAS – Trackside Automation System (hot box, hot wheel and blocked brake trackside detection system belongs to TAS)	
Other actors	<ul style="list-style-type: none"> • OM – Operations Manager • OAS – On-board Automation System • REP – Repository • IMS – Incident Management System • IM – Infrastructure Manager • TMS – Traffic Management System • OMTS – On-board Multimedia and Telematic Subsystem 	
Use case summary	A hot wheel due to brake failure is detected through trackside sensors. The vehicle shall stop immediately.	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA3, GoA4 • Operational category: passenger, freight, urban, regional, mainline and inspection vehicles 	
Main goal	Prevent damages due to a reached temperature limit, indicative of the condition of a bearing, above which damage will occur to the bearing and/or its functionality, with the potential to lead to a hazardous event.	
Preconditions	<ul style="list-style-type: none"> • Train is running. • Brake failure detected through trackside hot boxes detectors. • Failure reaction shall be "stop immediately". 	
Termination outcome	Successful outcomes	Outcome 1: Service brake is triggered Outcome 2: Stop in a suited area Outcome 3: Information to passengers Outcome 4: Appropriate reaction of IM / TMS

Use case field	Description	
	Unsuccessful outcomes	<p>Outcome 5: Emergency action not transmitted to APM. Outcome 6: No Service brake triggered. Outcome 7: Service brake triggered although not allowed by local specific requirements. Outcome 8: Emergency brake triggered instead SB. Outcome 9: Vehicle stops in a ETCS non-stopping area. Outcome 10: Vehicle stops in an unsuited place like tunnel or bridge. Outcome 11: No information about the stop to passengers. Outcome 12: No reactions of TMS (vehicle immobilised on a track). Outcome 13: No alarm/action actuated by IMS. Outcome 14: Any issue in standstill like open the doors.</p>
Condition affecting termination outcome	Outcomes	<p>Explanation for unsuccessful outcomes:</p> <ul style="list-style-type: none"> • Failure of monitoring components. • Communication issue between components. • Issues with APM: <ul style="list-style-type: none"> ○ No brake requested by APM ○ Brake requested despite not suited area ○ Wrong brake (EB) requested by APM • No brake triggered/applied by Train Protection. • Issue with HW component like brake valve. • Train attendant not informed in GoA 3. • No information through OMTS in GoA 3/4. • Intervention request not actuated by IMS. <p>Post-conditions for unsuccessful outcomes:</p> <ul style="list-style-type: none"> • Stop the vehicle. • Inform Operations Manager. • Act according Operations Manager indication. • Bring the vehicle to suited station (manually, with JP or rescue the vehicle) for a check. • Possibly evacuate the passengers. • Investigation of the issue.
Use case scenario	Step 1	TAS detects brake failure through hot boxes sensors.
	Step 2	TAS informs Operations Manager about the brake failure detection.
	Step 3	OM sends emergency action to APM via REP.
	Step 3.1	<i>Communication issue (outcome 5: emergency action not transmitted to APM).</i>
	Step 3.2	<i>Communication issue (outcome 6: no service brake triggered).</i>
	Step 4	APM requests a service brake.

Use case field	Description	
	Step 4.1	<i>No brake requested by APM (outcome 6: no service brake triggered).</i>
	Step 4.2	<i>Brake requested despite not suited area (outcome 7: service brake triggered although not allowed by local specific requirements).</i>
	Step 4.3	<i>Brake requested despite not suited area (outcome 9: Vehicle stops in a ETCS non-stopping area).</i>
	Step 4.4	<i>Brake requested despite not suited area (outcome 10: Vehicle stops in an unsuited place like tunnel or bridge).</i>
	Step 4.5	<i>Wrong brake (EB) requested by APM (outcome 8: Emergency brake triggered instead Service Brake).</i>
	Step 5	Train Protection (TP) applies service brake.
	Step 5.1	<i>HW- or SW-issue (outcome 6: no service brake triggered).</i>
	Step 6	Train is at standstill.
	Step 7	Train attendant (GoA 3) is informed via OM (if other, has to be defined, if OMTS see 7bis) about the situation.
	Step 7.1	<i>Train attendant not informed (outcome 11: no information about the stop to passengers).</i>
	Step 7bis	Information is provided through OMTS (GoA 3/4).
	Step 7bis.1	<i>No information provided by OMTS (outcome 11: no information about the stop to passengers).</i>
	Step 8	Appropriate reaction of IM (OM/IMS), IMS contacts TMS.
	Step 8.1	<i>No actions took, although vehicle blocked on the track (outcome 12: No reactions of TMS).</i>
	Step 9	IMS (or entities according to local prescriptions) actuates an intervention request (check of the vehicle).
	Step 9.1	<i>Request not actuated (outcome 13: no alarm/action actuated by IMS).</i>
	Step 10	Train is temporarily suspended and TMS updated.
Postcondition	<ul style="list-style-type: none"> • Train and hot wheels / boxes are checked. • If no damage (test case) --> perform brake test. • If damages (test case) --> train suspended. • TMS updated. • New JP is delivered if continuation of journey allowed. • Rescue and evacuation are planned if needed. 	

Use case field	Description
<p>Use case notes</p>	<p>The command cmd_ETCS_stop transmits an Emergency Stop message to the ETCS. This command shall not be used. An action on emergency brakes is not suitable because it can lead to a derailment. Communication through APM that will request the service brake (see APM_13.13) shall be privileged.</p> <p>Local specific requirements to be checked and implemented (see for example I-30064 and I-50099 in Switzerland).</p> <p>A mapping of the local communication ways between the different actors like OM, IMS and emergency services shall be done. It will help to identify possible delay, compare different implementation between countries and define if additional requirements are needed.</p> <p>In accordance with IM, test different reactions depending on:</p> <ul style="list-style-type: none"> • With/without speed reduction (if stop not immediately allowed). • Hot box alarm triggered in station while the train is running. • Possibility to light differ the service brake if the train is approaching a station (goal would be to stop in the station, easier to manage the passenger)? <p>Stopping in an unsuited area should be avoided by the location of the trackside sensors.</p> <p>Evaluate the elapsed time before intervention team will be at the vehicle. Management of the passengers in GoA 4 during this time?</p>

Table 1: Use case “Handle hot wheel due to brake failure - Brake failure detected through hot boxes detector: stop immediately” description

1.40 UC5.1-040: MANAGE FIRE ON-BOARD LOCOMOTIVE OR EMPTY PASSENGER TRAIN

Use case field	Description	
ID	UC5.1-040	
Use case name	Manage fire on-board locomotive or empty passenger train.	
Main actor	On-board Automation System (OAS)	
Other actors	<ul style="list-style-type: none"> • Emergency Manager • On Line Fire Detection System (OLFD) • Incident Management System (IMS) • Trackside Automation System (TAS) 	
Use case summary	<p>This use case is partially redundant with the use case '<i>UC5.1-041 Handle fire accident on passenger train – in station (at standstill) - detected by train unit</i>' and '<i>UC5.1-042 Handle fire accident on passenger train – running</i>'.</p> <p>The detection of fire, i.e., the trigger of this use case can be:</p> <ul style="list-style-type: none"> • On-board device detection • Trackside device detection 	
Applicability	<ul style="list-style-type: none"> • Geographical: European level. • System level: GoA3, GoA4. • Operational category: passenger, urban, regional, freight, mainline. 	
Main goal	<ul style="list-style-type: none"> • Reduce the damage of the train. • Reduce the damage of infrastructure. 	
Preconditions	<ul style="list-style-type: none"> • Fire alarm has been triggered. • For GoA3, and GoA4, the On-board Automation System (OAS) with subsystems like TCMS, APM, ADM, and ETCS is fully operational. • The Trackside Automation System (TAS) is fully operational. • The Fleet Automation System (FAS) is fully operational. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: <ul style="list-style-type: none"> ○ The train fire is extinguished. ○ The traffic is recovered soon from this accident.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2: <ul style="list-style-type: none"> ○ The train fire cannot be extinguished. ○ The traffic cannot be recovered soon from this accident.

Use case field	Description	
Condition affecting termination outcome	Outcome 2	<p>Explanations for unsuccessful outcomes:</p> <ul style="list-style-type: none"> • Fire is detected too late, and explosions occur. • Damage of infrastructure which blocks the fire brigade for rescue. • Wrong or incomplete information transmitted to the IMS. • Damage of infrastructure to recover normal traffic. <p>Post-conditions for unsuccessful outcomes:</p> <ul style="list-style-type: none"> • Rescue. • Service suspends for some traffic lines. • Accident investigation.
Use case scenario	Step 1	<p>The fire alarm can be triggered by the following actors:</p> <ul style="list-style-type: none"> • OAS. • OLF.D.
	Step 2	<p>The fire alarm is delivered to TAS in different ways:</p> <ul style="list-style-type: none"> • OAS → TAS. • OLF.D → TAS.
	Step 3	<p>TAS requests the actual train status:</p> <ul style="list-style-type: none"> • GoA3/4: TAS ↔ OAS.
	Step 4	<ul style="list-style-type: none"> • TAS informs IMS. • IMS: evaluates the situation and activate different emergency plan (EP).
	Step 4.1	<ul style="list-style-type: none"> • EP 1: When it is possible to stop the train at the next rescue point.
	Step 4.1.1	<ul style="list-style-type: none"> • OAS in GoA3/4: drive to next rescue point. • TAS: When inside the tunnel, turn-on tunnel lights, trigger ventilation when it is necessary to empty smoke, open emergency doors when the rescue point is inside the tunnel, close the tunnel to other traffic except rescue train. • IMS/Emergency Manager: organise fire brigade.
	Step 4.1.2	<ul style="list-style-type: none"> • TAS: specifically, in tunnel rescue point, block smoke in one tunnel tube. • TAS: set routing for the fire brigade
	Step 4.1.3	<ul style="list-style-type: none"> • Fire extinguishing when possible.
	Step 4.2	<ul style="list-style-type: none"> • EP 2: train can move, but not possible to achieve the next rescue point.
	Step 4.2.1	<ul style="list-style-type: none"> • TAS: Instruct OAS in GoA3/4 to the new stopping point (avoid a difficult stopping point such as inside the tunnel or on a bridge). • IMS/Emergency Manager: organise fire brigade.

Use case field	Description	
	Step 4.2.2	<ul style="list-style-type: none"> TAS: set routing for the fire fighting and rescue train.
	Step 4.2.3	<ul style="list-style-type: none"> Fire extinguishing when possible.
	Step 4.3	<ul style="list-style-type: none"> EP 3: when the train cannot move.
	Step 4.3.1	<ul style="list-style-type: none"> TAS: when inside the tunnel, turn-on tunnel lights, trigger ventilation when it is necessary to empty smoke, and open emergency doors when the rescue point is inside the tunnel. IMS/Emergency Manager: organise fire extinguish train.
	Step 4.3.2	<ul style="list-style-type: none"> TAS: set routing for the fire brigade.
	Step 4.3.3	<ul style="list-style-type: none"> Fire extinguishing when possible.
	Step 5	<ul style="list-style-type: none"> TAS: rerouting trains which to be affected in the accident area. TAS: inform maintenance group for necessary infrastructure check.
	Step 6	<ul style="list-style-type: none"> TAS: when the accident is resolved, recover the traffic in affected area.
Postcondition	<ul style="list-style-type: none"> Traffic in the affected area is recovered. The damage of train is reduced. The damage of infrastructure is reduced. 	
Use case notes	<p>Experience from the long base tunnel in Switzerland:</p> <ul style="list-style-type: none"> The early detection of fire or any rolling stock abnormal is important. In Switzerland, some long tunnels (e.g., Gotthard Base Tunnel, Lötschberg Base Tunnel, Ceneri Base Tunnel) are equipped with the Tunnel Automation System, which will trigger alarm when abnormal low train speed is detected inside the tunnel. An abnormal low speed might indicate some on-board malfunction. The malfunction might trigger fire in the end. The Gotthard Base Tunnel has two multifunctional stations (Faido and Sedrun) inside the tunnel as rescue points. Depending on the train status, the Tunnel Automation system will instruct the driver which rescue point to stop. For example, either outside the tunnel or one of the multifunctional stations. It is also necessary to evaluate the severity of the fire so as to react differently. 	

Table 1: Use case “Manage fire on-board locomotive or empty passenger train” description

1.41 UC5.1-041: HANDLE FIRE ACCIDENT ON PASSENGER TRAIN – IN STATION (AT STANDSTILL)

Use case field	Description				
ID	UC5.1-041				
Use case name	Handle fire accident on passenger train – in station (at standstill) - detected by train unit				
Main actor	On-board Automation System (OAS)				
Other actors	<ul style="list-style-type: none"> • On Line Fire Detection System (OLFD) • On-board Multimedia and Telematic Subsystem (OMTS) • Incident Management System (IMS) • Emergency Manager • Station Management • Trackside Automation System (TAS) • Operations Manager (OM) • Passengers • Travellers 				
Use case summary	<p>This use case is partially redundant with the use case 'UC5.1-042: Handle fire accident on passenger train – running'.</p> <p>This use case can be triggered not only by the detection from train unit, but also possible from trackside unit or people (railway staff, passengers, or travellers).</p>				
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA1, GoA2, GoA3, GoA4 • Operational category: passenger, urban, regional, mainline 				
Main goal	<ul style="list-style-type: none"> • Guarantee the safety of passengers on-board and on platform. • Reduce the damage of train. • Reduce the damage of infrastructure. 				
Preconditions	<ul style="list-style-type: none"> • Fire alarm has been triggered. • For GoA2, GoA3 and GoA4, the On-board Automation System (OAS) with subsystems like TCMS, ATO inclusive APM and ETCS fully operational. • For GoA1 and GoA2, driver fully operational. • The Trackside Automation System (TAS) fully operational. • The Fleet Automation System (FAS) fully operational. 				
Termination outcome	<table border="1"> <thead> <tr> <th>Successful outcomes</th> <th></th> </tr> </thead> <tbody> <tr> <td></td> <td> <ul style="list-style-type: none"> • Outcome 1: <ul style="list-style-type: none"> ○ Passengers and railway staff evacuated safely from the train with fire. ○ The fire is extinguished. ○ TAS is informed when the traffic can be recovered. ○ The damage of infrastructure is reduced. </td> </tr> </tbody> </table>	Successful outcomes			<ul style="list-style-type: none"> • Outcome 1: <ul style="list-style-type: none"> ○ Passengers and railway staff evacuated safely from the train with fire. ○ The fire is extinguished. ○ TAS is informed when the traffic can be recovered. ○ The damage of infrastructure is reduced.
Successful outcomes					
	<ul style="list-style-type: none"> • Outcome 1: <ul style="list-style-type: none"> ○ Passengers and railway staff evacuated safely from the train with fire. ○ The fire is extinguished. ○ TAS is informed when the traffic can be recovered. ○ The damage of infrastructure is reduced. 				

Use case field	Description	
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2: <ul style="list-style-type: none"> ○ Passengers and railway staff cannot evacuate safely. ○ The fire cannot be extinguished. ○ The traffic cannot be recovered soon from this accident. ○ The damage of infrastructure is huge.
Condition affecting termination outcome	Outcome 2	<p>Explanations for unsuccessful outcomes:</p> <ul style="list-style-type: none"> • Fire is detected too late, and explosions happened. • Damage of infrastructure which blocks the extinguish train for rescue. • Wrong or incomplete information transmitted to the IMS. • Damage of infrastructure which blocks to recover normal traffic. <p>Post-conditions for unsuccessful outcomes:</p> <ul style="list-style-type: none"> • Rescue. • Service suspends for some traffic lines. • Accident investigation.
Use case scenario	Step 1	<p>The fire alarm can be triggered by the following actors:</p> <ul style="list-style-type: none"> • Passenger or Train attendant • OAS • OLFD • Travellers
	Step 2	<p>The fire alarm is delivered to TAS in different ways:</p> <ul style="list-style-type: none"> • Passenger / Train attendant à OAS à TAS • OAS à TAS • OLFD à TAS • Travellers à ISM
	Step 3	<p>TAS: inform IMS.</p> <p>IMS: evaluate the situation (including verification of false alarm) and activate emergency plan.</p>
	Step 3.1	<ul style="list-style-type: none"> • OMTS and/or On-board Staff: instruct passengers on-board. • Station Management: instruct passengers and travellers on platform. • IMS/Emergency Manager: organise passenger rescue. • IMS/Emergency Manager: organise fire extinguish train (or fire brigade). • Activate self-extinguish system if there is any on board and it is not activated automatically. • Switch off the distribution of dangerous voltage (230 VAC) for the respective coach if it is present. Internal lighting (emergency lighting for sure) shall remain functional.

Use case field	Description	
	Step 3.2	<ul style="list-style-type: none"> • Driver and/or On-board Staff in GoA1/2: open the door, • OAS and/or On-board Staff in GoA3/4: open the door, • OMTS and/or On-board Staff: If not possible to open the door, break the window and/or instruct passengers to do so.
	Step 3.3	<ul style="list-style-type: none"> • Passengers: evacuation
	Step 3.4	<ul style="list-style-type: none"> • IMS/Emergency Manager: passenger rescue
	Step 3.5	<ul style="list-style-type: none"> • Fire extinguishing when possible
	Step 4	<ul style="list-style-type: none"> • TAS acts according to IMS-ISM emergency plan
	Step 4.1	<ul style="list-style-type: none"> • TAS: set routing for the firefighting train. • TAS: rerouting trains which were affected to the accident area.
	Step 4.2	<ul style="list-style-type: none"> • TAS: evacuation of other train in stations if necessary
	Step 4.3	<ul style="list-style-type: none"> • TAS: inform maintenance group for necessary infrastructure check
	Step 5	<ul style="list-style-type: none"> • TAS: informed when the accident is resolved, recover the traffic in affected area
Postcondition	<ul style="list-style-type: none"> • Passengers are safely evacuated. • Traffic in the affected area is recovered. 	
Use case notes	<ul style="list-style-type: none"> • It is also necessary to evaluate the severity of the fire so as to react differently. • Procedure can be different depending on the local prescription. The process after the trigger of the alarm shall be documented for each scenario (acknowledgment request, other checks, etc.). 	

Table 1: Use case “Handle fire accident on passenger train – in station” description

1.42 UC5.1-042: HANDLE FIRE ACCIDENT ON PASSENGER TRAIN – RUNNING

Use case field	Description		
ID	UC5.1-042		
Use case name	Handle fire accident on passenger train - Running		
Main actor	On-board Automation System (OAS)		
Other actors	<ul style="list-style-type: none"> • On Line Fire Detection System (OLFD) • On-board Multimedia and Telematic Subsystem (OMTS) • Incident Management System (IMS) • Emergency Manager • Trackside Automation System (TAS) • Operations Manager (OM) • Passengers 		
Use case summary	<p>This use case describes the procedure for the detection of the detection of fire, i.e., the trigger of this use case can be:</p> <ul style="list-style-type: none"> • Passenger report • Train attendant (GoA1-3) report • Driver (GoA1-2) report • On-board device detection • Trackside device detection 		
Applicability	<ul style="list-style-type: none"> • Geographical: European level. • System level: GoA1, GoA2, GoA3, GoA4. • Operational category: passenger, urban, regional, mainline. 		
Main goal	<ul style="list-style-type: none"> • Guarantee the safety of passengers. • Reduce the damage of train. • Reduce the damage of infrastructure. 		
Preconditions	<ul style="list-style-type: none"> • Fire alarm has been triggered. • For GoA2, GoA3 and GoA4, the On-board Automation System (OAS) with subsystems like TCMS, ATO inclusive APM and ETCS fully operational. • For GoA2, driver fully operational. • The Trackside Automation System (TAS) fully operational. • The Fleet Automation System (FAS) fully operational. 		
Termination outcome	<table border="1"> <thead> <tr> <th>Successful outcomes</th> </tr> </thead> <tbody> <tr> <td> <ul style="list-style-type: none"> • Outcome 1: <ul style="list-style-type: none"> ○ The train stops at safe location, ○ Passengers evacuated safely from the train with fire, ○ The train is extinguished, ○ TAS is informed when the traffic can be recovered. </td> </tr> </tbody> </table>	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: <ul style="list-style-type: none"> ○ The train stops at safe location, ○ Passengers evacuated safely from the train with fire, ○ The train is extinguished, ○ TAS is informed when the traffic can be recovered.
Successful outcomes			
<ul style="list-style-type: none"> • Outcome 1: <ul style="list-style-type: none"> ○ The train stops at safe location, ○ Passengers evacuated safely from the train with fire, ○ The train is extinguished, ○ TAS is informed when the traffic can be recovered. 			

Use case field	Description	
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2: <ul style="list-style-type: none"> ○ The train did not reach the safe stopping point within 15 min. ○ The train cannot stop at safe location. <ul style="list-style-type: none"> ▪ Overshoot or short of a stopping point ▪ Stop at danger locations (e.g., long bridge, tunnel, etc.) ○ Passengers are not evacuated safely, ○ The train cannot be extinguished, ○ The traffic cannot be recovered soon from this accident.
Condition affecting termination outcome	Outcome 2	<p>Explanations for unsuccessful outcomes:</p> <ul style="list-style-type: none"> • Fire is detected too late, and explosions happened. • Train is stuck at difficult locations (e.g., long bridge, tunnel without evacuation path). • Damage of infrastructure which blocks the extinguish train for rescue. • Wrong or incomplete information transmitted to the extinguish rescue centre. • Damage of infrastructure to recover normal traffic. <p>Post-conditions for unsuccessful outcomes:</p> <ul style="list-style-type: none"> • Rescue. • Service suspends for some traffic lines. • Accident investigation.
Use case scenario	Step 1	<p>The fire alarm can be triggered by the following actors:</p> <ul style="list-style-type: none"> • Passenger, Driver or Train attendant • OAS • OLF • Any eyewitness
	Step 2	<p>The fire alarm is delivered to TAS in different ways:</p> <ul style="list-style-type: none"> • Passenger / Train attendant à OAS à TAS • OAS à TAS • OLF à TAS • Eyewitness à TAS
	Step 3	<p>TAS requests the actual train status:</p> <ul style="list-style-type: none"> • GoA1/2/3: TAS a Operations Manager a train attendant / driver, • GoA3/4: TAS a OAS
	Step 4	<p>TAS informs IMS.</p> <p>IMS: evaluate the situation (including verification of false alarm) and activate different emergency plan.</p>
	Step 4.1	<p>Plan 1: when it is possible to stop the train at next rescue point.</p>

Use case field	Description
	Step 4.1.1 <ul style="list-style-type: none"> • Driver in GoA1/2: drive to next rescue point • OAS in GoA3/4: drive to next rescue point • OMTS: instruct passengers, move them to a safer zone if possible. • TAS: when inside the tunnel, turn-on tunnel lights, trigger ventilation when it is necessary to empty smoke, open emergency doors when the rescue point is inside the tunnel, close the tunnel to other traffic except rescue train. • IMS/Emergency Manager: organise passenger rescue. • IMS/Emergency Manager: organise fire brigade.
	Step 4.1.2 <ul style="list-style-type: none"> • Driver in GoA1/2: open the door. • OAS in GoA3/4: open the door. • OMTS: If not possible to open the door, instruct to break the window.
	Step 4.1.3 <ul style="list-style-type: none"> • Passengers: evacuation
	Step 4.1.4 <ul style="list-style-type: none"> • IMS/Emergency Manager: passenger rescue. • TAS: specifically in tunnel rescue point, when all passengers have evacuated, block smoke in one tunnel tube. • TAS: set routing for the fire extinguish train.
	Step 4.1.5 <ul style="list-style-type: none"> • Fire extinguishing when possible. <p>Continue with Step 5.</p>
	Step 4.2 <p>Plan 2: train can move, but OAS evaluates that the train is not possible to achieve next rescue point.</p>
	Step 4.2.1 <ul style="list-style-type: none"> • TAS: instruct Driver in GoA1/2 or OAS in GoA3/4 to the stopping point (avoid a difficult stopping point such as inside the tunnel or on a bridge). • OMTS: instruct passengers, move them to a safer zone if possible. • IMS/Emergency Manager: organise passenger rescue. • IMS/Emergency Manager: organise fire extinguish train.
	Step 4.2.2 <ul style="list-style-type: none"> • Driver in GoA1/2: open the door. • OAS in GoA3/4: open the door. • OMTS: If not possible to open the door, instruct to break the window.
	Step 4.2.3 <ul style="list-style-type: none"> • Passengers: evacuation
	Step 4.2.4 <ul style="list-style-type: none"> • IMS/Emergency Manager: passenger rescue. • TAS: set routing for the fire extinguish train. <p>Continue with Step 5.</p>
	Step 4.3 <p>Plan 3: when the train cannot move</p>

Use case field	Description	
	Step 4.3.1	<ul style="list-style-type: none"> • OMTS: instruct passengers, move them to a safer zone if possible. • TAS: when inside the tunnel, turn-on tunnel lights, trigger ventilation when it is necessary to empty smoke, open emergency doors when the rescue point is inside the tunnel. • IMS/Emergency Manager: organise passenger rescue. • IMS/Emergency Manager: organise fire extinguish train.
	Step 4.3.2	<ul style="list-style-type: none"> • Driver in GoA1/2: open the door. • OAS in GoA3/4: open the door. • OMTS: If not possible to open the door, instruct to break the window.
	Step 4.3.3	Passengers: evacuation.
	Step 4.3.4	<ul style="list-style-type: none"> • IMS/Emergency Manager: passenger rescue • TAS: specifically in tunnel rescue point, when all passengers have evacuated, block smoke in one tunnel tube. • TAS: set routing for the fire extinguish train.
	Step 5	<ul style="list-style-type: none"> • TAS: rerouting trains which to be affected in the accident area. • TAS: inform maintenance group for necessary infrastructure check.
	Step 6	TAS: when the accident is resolved, recover the traffic in affected area.
Postcondition	<ul style="list-style-type: none"> • Passengers are safely evacuated. • Traffic in the affected area is recovered. 	

Use case field	Description
<p>Use case notes</p>	<p>Linked X2Rail-4 – This use case is related to the following X2Rail-4 ATO specifications:</p> <ul style="list-style-type: none"> • ATO Operational Scenario v1.12: R21 fire on-board while running, • SRS v0.3.0 UCs 13.9.6 Fire on board while running. <p>Experience from the long base tunnel in Switzerland:</p> <ul style="list-style-type: none"> • The early detection of fire or any rolling stock abnormal is important. In Switzerland, some long tunnels (e.g., Gotthard Base Tunnel, Lötschberg Base Tunnel, Ceneri Base Tunnel) are equipped with the Tunnel Automation System, which will trigger alarm when abnormal low train speed is detected inside the tunnel. An abnormal low speed might indicate some on-board malfunction. The malfunction might trigger fire in the end. • The Gotthard Base Tunnel has two multifunctional stations (Faido and Sedrun) inside the tunnel as rescue points. Depending on the train status, the Tunnel Automation system will instruct the driver which rescue point to stop. For example, either outside the tunnel or one of the multifunctional stations. <p>It is also necessary to evaluate the severity of the fire so as to react differently.</p>

Table 1: Use case “Handle fire accident on passenger train - running” description

1.43 UC5.1-043: HANDLE FIRE ALARM TUNNEL - FIRE ALARM SYSTEMS TUNNEL – NO TRAIN UNIT RUN AFFECTED

Use case field	Description	
ID	UC5.1-043	
Use case name	Handle fire alarm tunnel - Fire alarm systems Tunnel - no train unit run affected	
Main actor	Trackside Automation System (TAS)	
Other actors	<ul style="list-style-type: none"> • On-board Automation System (OAS) • Infrastructure Manager (IM) • Emergency Manager (EM) • Police officers • Fire fighters 	
Use case summary	<p>This use case details the actions to be taken when a fire alarm in a tunnel is triggered without any train unit being immediately affected in the tunnel.</p> <p><i>Please note, that each tunnel (or tunnel complex) may have different characteristics covered in specific tunnel emergency and evacuation plans. This use case only aims at depicting a general procedure. Local rules apply.</i></p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European • System level: Infrastructure System (GoA3/4) • Operational category: passenger, urban, regional, mainline, freight, maintenance 	
Main goal	<p>The main objective is to</p> <ul style="list-style-type: none"> • Prevent train units from entering the tunnel. • Inform relevant stakeholders. • Secure external and internal stakeholders from hazards due to railway operations. 	
Preconditions	<ul style="list-style-type: none"> • Fire (smoke or heat) detection system in tunnel in place • No train units in affected line section (tunnel) 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Track restrictions in place on affected line sections; OLE powered down and grounded for other stakeholders; Relevant stakeholders are informed. • Outcome 2: Track restrictions in place on affected line sections; Relevant stakeholders are informed.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Train Units enter the tunnel prior to inspection or completed fire control measures -> see use case 'UC5.1-044 Handle fire alarm tunnel - Fire alarm systems Tunnel - min. one train unit run affected'.
Condition affecting termination outcome	Outcome 2	<ul style="list-style-type: none"> • Track or track sections not equipped with overhead line or third rail.
Use case scenario	Step 1	Fire detection system in tunnel reports fire to TAS.

Step 2	TAS registers incident
Step 3	TAS assesses situation: <ul style="list-style-type: none"> • TAS identifies affected line sections. • TAS identifies affected train units. • TAS identifies specific tunnel safety procedures. • TAS gathers information on available tunnel equipment (e.g., wind direction measurement if available).
Step 4	TAS: <ul style="list-style-type: none"> • Commands usage restrictions to affected line sections according to rule set. • Reports to IM, EM. • Commands a power down of traction current section of affected line sections.
Step 4.1	TAS <ul style="list-style-type: none"> • commands usage restrictions to affected line sections according to rule set and • reports to IM, EM.
Step 4.2	OAS on affected train units receive updated journey profiles due to line restrictions.
Step 4.3	IM receives reports with all necessary information and assesses situation.
Step 4.4	IM or TAS requests fire fighters and police officers (with warning that OLE/third rail being active – if applicable).
Step 4.5	➔ Outcome 2: Track restrictions in place on affected line sections; Relevant stakeholders are informed.
Step 5	OAS on affected train units receive updated journey profiles due to line restrictions.
Step 6	TAS receives acknowledgement that traction current section is powered down.
Step 7	TAS commands remotely grounding of traction current section.
Step 7.1	TAS reports to IM, EM, fire brigades that grounding of OLE / short-circuiting of third-rail of affected line section is necessary (incl. confirmation of traction current section being powered down).
Step 7.2	EM arrives on-site and grounds OLE or short-circuits third rail.
Step 7.3	EM confirms to TAS that OLE is grounded or third rail is short-circuited.

	<p>→ to Step 8</p>
Step 8	TAS receives acknowledgement that traction current section is grounded and reports to IM, EM and fire brigades.
Step 9	OAS on affected train units receive updated journey profiles due to line restrictions.
Step 10	→ Outcome 1: Track restrictions in place on affected line sections; OLE powered down and grounded for other stakeholders; Relevant stakeholders are informed
Postcondition	<ul style="list-style-type: none"> OLE/third rail stays powered down and grounded until intentionally powered back on. Recovery actions can be started (firefighting/investigating). No train units in affected line section (tunnel) and track restrictions in place (full track closure).
Use case notes	<p>The procedures to ground the OLE might differ between the infrastructure managers or even locally as third parties (e.g., fire brigades) might have different responsibilities and authorisations.</p> <p>Sources:</p> <ul style="list-style-type: none"> 484.0011 Brandmeldeanlage (BMA) 423.0233 Aufgaben der Notfalleitstelle bei der Abwicklung von Ereignissen 423.0234 Aufgaben des Fahrdienstleiters bei der Abwicklung von Ereignissen 12300 Notfallmanagement Eisenbahnbetrieb

Table 1: Use case “Handle fire alarm tunnel - Fire alarm systems Tunnel - no train unit run affected” description

1.44 UC5.1-044: HANDLE FIRE ALARM TUNNEL - FIRE ALARM SYSTEMS TUNNEL – AT LEAST ONE TRAIN UNIT AFFECTED

Use case field	Description				
ID	UC5.1-044				
Use case name	Handle fire alarm tunnel - Fire alarm systems Tunnel – at least one train unit affected				
Main actor	Trackside Automation System (TAS)				
Other actors	<ul style="list-style-type: none"> • On-board Automation System (OAS) • Infrastructure Manager (IM) • Emergency Manager (EM) • Railway Undertaking Supervisor (RUS) • Police officers • Fire fighters 				
Use case summary	<p>This use case details the actions to be taken when a fire alarm in a tunnel is triggered with at least one train unit inside affected tunnel.</p> <p><i>Please note, that each tunnel (or tunnel complex) may have different characteristics covered in specific tunnel emergency and evacuation plans. This use case only aims at depicting a general procedure. Local rules apply.</i></p> <p><i>Remark: The re-routing of a train unit to a safe stopping point in tunnel are covered by use cases UC5.1.ADIF-30 and 'UC5.1-057 Evacuation and emergency procedures'.</i></p>				
Applicability	<ul style="list-style-type: none"> • Geographical: European • System level: Infrastructure System (GoA3/4) • Operational category: passenger, urban, regional, mainline, freight, maintenance 				
Main goal	<p>The main objective is to:</p> <ul style="list-style-type: none"> • Prevent train unit(s) scheduled with a route set through the tunnel from entering the tunnel**. • Ensure that train unit(s) inside the tunnel can leave safely. • Inform relevant stakeholders. • Secure external and internal stakeholders from hazards due to railway operations. 				
Preconditions	<ul style="list-style-type: none"> • Fire (smoke or heat) detection system in tunnel in place • One or several train unit(s) inside the tunnel and/or about to enter the tunnel 				
Termination outcome	<table border="1"> <thead> <tr> <th>Successful outcomes</th> <th></th> </tr> </thead> <tbody> <tr> <td></td> <td> <ul style="list-style-type: none"> • Outcome 1: Track restrictions in place on affected line sections; OLE/third rail powered down and grounded for other stakeholders; Relevant stakeholders are informed; affected train unit(s) left affected line sections. • Outcome 2: Track restrictions in place on affected line sections; Relevant stakeholders are informed; affected train unit/s left affected line sections. </td> </tr> </tbody> </table>	Successful outcomes			<ul style="list-style-type: none"> • Outcome 1: Track restrictions in place on affected line sections; OLE/third rail powered down and grounded for other stakeholders; Relevant stakeholders are informed; affected train unit(s) left affected line sections. • Outcome 2: Track restrictions in place on affected line sections; Relevant stakeholders are informed; affected train unit/s left affected line sections.
Successful outcomes					
	<ul style="list-style-type: none"> • Outcome 1: Track restrictions in place on affected line sections; OLE/third rail powered down and grounded for other stakeholders; Relevant stakeholders are informed; affected train unit(s) left affected line sections. • Outcome 2: Track restrictions in place on affected line sections; Relevant stakeholders are informed; affected train unit/s left affected line sections. 				

Condition affecting termination outcome	Unsuccessful outcomes	<p>➔ Outcome 3: (One or more) Affected train unit(s) require safe stopping point.</p> <p>This outcome will rather be an interruption of this use case as the procedure for the safe stopping points (in tunnel) need to be done. This use case may proceed again after the stopping of a train with step 9.</p>
	Outcome 2	<p>➔ Affected line sections not equipped with OLE or third rail.</p>
Use case scenario	Step 1	Fire detection system in tunnel reports fire to TAS.
	Step 2	TAS registers incident.
	Step 3	<p>TAS assesses situation:</p> <ul style="list-style-type: none"> • TAS identifies affected line sections. • TAS identifies affected train unit(s). • TAS identifies specific tunnel safety procedures. • TAS gathers information on available tunnel equipment (e.g., wind direction measurement if available).
	Step 4	<p>TAS</p> <ul style="list-style-type: none"> • commands usage restrictions (entry restrictions) to affected line sections according to rule set*. • commands powering on of tunnel lights (if available). • reports to IM, EM and RUS.
	Step 5	IM receives reports with all necessary information and assesses situation.
	Step 5.1	IM confirms to TAS to take over control of the accident.
	Step 5.2	➔ Step 6 but where IM OR TAS is written, only IM acts
	Step 6	IM or TAS requests fire fighters and police officers (with warning that traffic is not yet stopped and OLE/third rail being active – if applicable).
	Step 7	OAS on affected train unit(s) receive updated journey profiles due to line restrictions.
	Step 7.1	TAS (or IM***) commands re-routing (stopping point) for selected affected unit/s due to inability to leave affected line sections.
Step 7.2	<p>➔ Outcome 3: (One or more) Affected Train Unit/s require safe stopping point à see use case UC5.1.ADIF-30 and use case UC5.1.ADIF-31.</p> <p>This outcome will rather be an interruption as the procedure for the safe stopping points (in tunnel) need to be done. This use case may proceed again after the</p>	

		stopping of a train with step 9 (in parallel with steps for tunnel evacuation – not covered here).
	Step 8	Affected train unit/s leave affected line sections.
	Step 8.1	(Not all) affected train unit/s can leave affected line sections.
	Step 8.2	<p>➔ Outcome 3: (One or more) Affected Train Unit/s unable to leave the tunnel due to obstructions require safe stopping point.</p> <p>This outcome will rather be an interruption as the procedure for the safe stopping points (in tunnel) need to be done. This use case may proceed again after the stopping of a train with step 9 (in parallel with steps for tunnel evacuation – not covered here).</p>
	Step 9	TAS confirms to EM and fire brigades that traffic is stopped on affected line section (but OLE/third rail is still powered on, if applicable).
	Step 10	TAS commands a power down of traction current section of affected line sections.
	Step 10.1	<p>This outcome applies to tunnels not equipped with OLE/third rail.</p> <p>➔ Outcome 2: Track restrictions in place on affected line sections; Relevant stakeholders are informed; affected train unit/s left affected line sections</p>
	Step 11	TAS commands remotely grounding of traction current section.
	Step 11.1	TAS reports to EM and fire brigades that grounding of OLE / short-circuiting of third-rail of affected line section is necessary (incl. confirmation of traction current section being powered down).
	Step 11.2	EM arrives on-site and grounds OLE or short-circuits third rail.
	Step 11.3	<p>EM confirms to IM (and/or TAS) that OLE is grounded or third rail is short-circuited.</p> <p>➔ to Step 12</p>
	Step 12	TAS receives acknowledgement that traction current section is grounded and reports to (IM), EM and fire brigades
	Step 13	<ul style="list-style-type: none"> • Outcome 1: Track restrictions in place on affected line sections; OLE/third rail powered down and grounded for other stakeholders; Relevant

		stakeholders are informed; affected train unit/s left affected line sections.
Postcondition	<ul style="list-style-type: none"> OLE/third rail stays powered down and grounded until intentionally powered back on Recovery actions can be started (fire fighting/investigating) No train unit(s) in affected line section (tunnel) and track restrictions in place (full track closure) 	
Use case notes	<p>*The rule set here would imply that any train unit inside the tunnel can leave unrestricted (if possible), but other train unit(s) cannot enter.</p> <p>**Scheduled train unit(s) refer to train unit(s) with a route set through the tunnel. Rescue train unit(s) may enter the tunnel if necessary.</p> <p>***The emergency manager of the IM is always able to control the situation if adjustments need to be made (in a critical emergency situation). Otherwise, the TAS is going to decide based on the rules for the respective situations set.</p> <p>Sources:</p> <ul style="list-style-type: none"> 484.0011 Brandmeldeanlage (BMA) 423.0233 Aufgaben der Notfallleitstelle bei der Abwicklung von Ereignissen 423.0234 Aufgaben des Fahrdienstleiters bei der Abwicklung von Ereignissen 12300 Notfallmanagement Eisenbahnbetrieb 	

Table 1: Use case “Handle fire alarm tunnel - Fire alarm systems Tunnel - train unit run affected” description

1.45 UC5.1-045: HANDLE FAILURE OF TILTING TECHNOLOGY INFRASTRUCTURE - MALFUNCTION

Use case field	Description	
ID	UC5.1-045	
Use case name	Handle failure of tilting technology infrastructure - Malfunction	
Main actor	On-board automation system (OAS)	
Other actors	<ul style="list-style-type: none"> • On-board automation system (OAS) on train unit 2 (TU2) • Trackside automation system (TAS) 	
Use case summary	This use case describes the procedure to restrict tilting trains due to failures of the infrastructure equipment (failure in data transmission from data point like balises or missing data point). The aim of the restriction is to avoid following tilting brakes to stop (forced brake) due to failures or missing data points and operate without interruption.	
Applicability	<ul style="list-style-type: none"> • Geographical: National • System level: System GoA3/4 • Operational category: passenger, urban, regional, mainline 	
Main goal	The main goal is to verify the failure and to inform relevant stakeholders (infrastructure manager) about the incident while allowing operations by tilting trains using the infrastructure to run smoothly.	
Preconditions	<ul style="list-style-type: none"> • Tilting train detected a failure in data transmission from data point 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Usage restriction for track is in place, failure of infrastructure; IM and RUS are informed.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2: Failure of tilting technology can be retraced to single train unit à failure on-board; usage restriction is lifted; the IM and RUS is informed.
Condition affecting termination outcome	Outcome 2	<ul style="list-style-type: none"> • Other train units utilising the data point do not reproduce the failure. • Tilting on this train is disabled and a speed restriction is applied. • TAS is informed about lower performance and calculates new timetable.
Use case scenario	Step 1	OAS (TU1) reports to TAS failure of tilting technology on-board due to missing data transmission from data point.
	Step 2	TAS assesses situation.
	Step 3	TAS commands: <ul style="list-style-type: none"> • Usage restriction for track section (speed limit for tilting trains) • Reports to IM, RUS

	Step 4	OAS (TU2) passes data point and reports same failure
	Step 4.1	OAS (TU2) passes data point without failure
	Step 4.2	TAS: <ul style="list-style-type: none"> • lifts usage restriction for track • reports to IM, RUS
	Step 4.3	➔ Outcome 2: Failure of tilting technology can be retraced to single train unit à failure on-board; usage restriction is lifted
	Step 5	TAS commands: <ul style="list-style-type: none"> • Usage restriction for track section (restricted use of tilting technology). • Reports to IM. • Calculates new timetable.
	Step 6	➔ Outcome 1: Usage restriction for track is in place, failure of infrastructure; IM and RUS is informed.
Postcondition		<ul style="list-style-type: none"> • Usage restriction is in place for train units using the tilting technology
Use case notes	<p>The process here is subject to the tilting technology used in railway operations and if there is trackside equipment, e.g., balises transmitting tilting information to the train unit, installed by the respective infrastructure manager. The exact behaviour in case of a missing data point or failed data transmission might differ depending on the solution utilised.</p> <p>Sources:</p> <ul style="list-style-type: none"> • 819.1330 GNT-Streckeneinrichtungen planen 	

Table 1: Use case “Handle failure of tilting technology infrastructure - Malfunction of tilting technology Infrastructure” description

1.46 UC5.1-046: HANDLE FAILURE OF EQUIPMENT OR SITUATIONS IN PASSENGER CABIN – SUSPENSION FAILURE

Use case field	Description	
ID	UC5.1-046	
Use case name	Handle failure of equipment or situations in passenger cabin – Suspension failure	
Main actor	On-board Automation System (OAS)	
Other actors	<ul style="list-style-type: none"> • Trackside Automation System (TAS) • Fleet manager • Railway Undertaking Supervisor • Incident Management System (IMS) 	
Use case summary	This use case describes the needs and the possible solutions to handle failure of rolling stock equipment, specifically to the air suspension damage for passenger trains.	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA3, GoA4 • Operational category: passenger, urban, regional, mainline 	
Main goal	<ul style="list-style-type: none"> • Ensure the anomaly can stop at next station or rescue point. • Ensure passengers can move to a safer zone. 	
Preconditions	<ul style="list-style-type: none"> • The On-board Automation System with subsystems like TCMS, ATO and ETCS are in operation. • Emergency suspension is still working. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: The anomaly train stops at next station or rescue point. The request for the maintenance of the anomaly train is delivered.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2: The air suspension cannot be empty.
Condition affecting termination outcome	Outcome 2	<p>Explanations for unsuccessful outcomes:</p> <ul style="list-style-type: none"> • OAS fails to detect the air suspension damage, • TAS fails to generate an appropriate Journey Profile to guide the anomaly train stops at next station or rescue point, • Mechanical failures to empty the air suspension. <p>Post-conditions for unsuccessful outcomes:</p> <ul style="list-style-type: none"> • The train may be towed away.
Use case scenario	Step 1	OAS detects an air suspension failure.
	Step 2	OAS sets the train related speed restriction.
	Step 3	OAS informs TAS about the incident and the restrictions.
	Step 4	OAS checks whether the train is currently moving.

	Step 4.1	When train is moving, TAS calculates a new Journey Profile to guarantee the running train can stop at next station or rescue point.
	Step 4.2	OAS stops the train as per new Journey Profile. Continue to Step 5.
	Step 5	When the train is at standstill, OAS vents the air suspension and waits until the air suspension is fully empty.
	Step 5.1	If the air suspension cannot be emptied, go to Outcome 2.
	Step 6	OAS reports firstly to the FAS. FAS on his part, coordinates the failure information with Fleet Manager and Railway Undertaking Supervisor to organise necessary maintenance of this train.
	Step 7	IM and RUS decide whether the train can continue in service when the air suspension is fully empty.
	Step 7.1	When it is decided by both IM (IMS) and RU (Fleet Manager and Railway Undertaking Supervisor) that the train can continue in service, <ul style="list-style-type: none"> • OAS generates any train related speed restriction. • TAS generates a new Journey Profile. • OAS supervises speed restriction.
	Step 7.2	When it is decided by both IM (IMS) and RU (Fleet Manager and Railway Undertaking Supervisor) that the train should be out of service, <ul style="list-style-type: none"> • Fleet Manager and Railway Undertaking Supervisor organise the necessary maintenance.
Postcondition	The suspension failure of the serviceable train is correctly handled.	
Use case notes	N/A	

Table 1: Use case “Handle failure of equipment or situations in passenger cabin – suspension failure” description

**1.47 UC5.1-047: HANDLE INFRASTRUCTURE RESTRICTIONS ORDERED BY
AUTHORITIES – BOMB ALARM ON TRAIN**

Use case field	Description								
ID	UC5.1-047								
Use case name	Handle infrastructure restrictions ordered by authorities - Bomb alarm on train								
Main actor	Trackside Automation System (TAS)								
Other actors	<ul style="list-style-type: none"> • Infrastructure Manager (IM) • Police • Railway Undertaking Supervisor (RUS) • On-board Automation System (OAS) • Train Attendant (TA) <i>optional</i> • Infrastructure Manager Station (IM (station)) • Emergency Manager (EM) • Railway Mobile Staff (RMS) 								
Use case summary	<p>This use case describes the procedure to handle a bomb alarm on a train unit in passengers' operations. The evacuation of the train unit is part of this use case.</p> <p>The bomb alarm was registered by the relevant police entities.</p> <p>The system under consideration can only support to implement measures. The overall handling strategy is subject to the relevant authorities (police) and the IM. The focus here is to handle infrastructure restrictions by the authorities and detail how the system behaves.</p>								
Applicability	<ul style="list-style-type: none"> • Geographical: European • System level: System GoA3/4 • Operational category: passenger, urban, regional, mainline 								
Main goal	The main goal is to re-route the train according to the order by the police entities responsible, restrict infrastructure usage and evacuate the train.								
Preconditions	<ul style="list-style-type: none"> • Train Unit is en-route in passenger service. • Bomb alarm was forwarded by the original recipient to the police (either directly or via other stakeholders). 								
Termination outcome	<table border="1"> <thead> <tr> <th>Successful outcomes</th> <th></th> </tr> </thead> <tbody> <tr> <td></td> <td> <ul style="list-style-type: none"> • Outcome 1: Passengers and personnel have left the affected train unit; Police takes over the further handling of the situation; Traffic is halted in the affected area; All relevant stakeholders are informed. • Outcome 2: Train is stopped en-route (not at a platform); Assisted evacuation en-route ordered; Police takes over further handling of the situation; All relevant stakeholders are informed. </td> </tr> <tr> <th>Unsuccessful outcomes</th> <th></th> </tr> <tr> <td></td> <td> <ul style="list-style-type: none"> • Train unit continues mission -> non-compliance with police order and investigation </td> </tr> </tbody> </table>	Successful outcomes			<ul style="list-style-type: none"> • Outcome 1: Passengers and personnel have left the affected train unit; Police takes over the further handling of the situation; Traffic is halted in the affected area; All relevant stakeholders are informed. • Outcome 2: Train is stopped en-route (not at a platform); Assisted evacuation en-route ordered; Police takes over further handling of the situation; All relevant stakeholders are informed. 	Unsuccessful outcomes			<ul style="list-style-type: none"> • Train unit continues mission -> non-compliance with police order and investigation
	Successful outcomes								
	<ul style="list-style-type: none"> • Outcome 1: Passengers and personnel have left the affected train unit; Police takes over the further handling of the situation; Traffic is halted in the affected area; All relevant stakeholders are informed. • Outcome 2: Train is stopped en-route (not at a platform); Assisted evacuation en-route ordered; Police takes over further handling of the situation; All relevant stakeholders are informed. 								
Unsuccessful outcomes									
	<ul style="list-style-type: none"> • Train unit continues mission -> non-compliance with police order and investigation 								

		<p>-> pro-longed exposure of risk of bomb attack for passengers and personnel on-board</p> <ul style="list-style-type: none"> • Wrong train unit identified by authorities (police) • Train unit is routed and stopped at another evacuation point without coordination from the police <p>-> police units cannot act in time due to confusion on stopping point and possible mix-up of train units</p> <p>-> quick evacuation efforts hindered</p> <p>-> non-compliance with common procedure</p> <ul style="list-style-type: none"> • Bomb alarm turns into bomb attack (explosion) before reaching the location for evacuation
Condition affecting termination outcome	Outcome 2	<ul style="list-style-type: none"> • Police orders train unit to be evacuated en-route
Use case scenario	Step 1	IM registers report on bomb alarm by police*
	Step 2	IM informs RUS of all affected (directly and indirectly) train units****
	Step 3	IM prioritises train units**** for evacuation
	Step 4	IM provides TAS with instructions to re-route non-affected train units**** and initiate preventative evacuation of affected areas and affected train unit
	Step 4.1 (stop en-route)	IM provides TAS with instructions to stop the directly affected train unit en-route (not at platform) and restrictions for tracks.
	Step 4.2 (stop en-route)	TAS registers incident and assesses situation
	Step 4.3 (stop en-route)	<p>TAS</p> <ul style="list-style-type: none"> • Routes directly affected train unit to suitable evacuation point as defined by the police. • Restricts track usage of tracks at suitable evacuation point. • Reports to RUS of affected train unit, IM and EM.
	Step 4.3.1 (stop en-route with TA)	<p>TAS</p> <ul style="list-style-type: none"> • Routes directly affected train unit to suitable evacuation point as defined. • Restricts track usage of tracks at suitable evacuation point. • Reports to RUS of affected train unit, IM and EM. • Reports to TA on-board (if available).
	Step 4.3.2 (stop en-route with TA)	<ul style="list-style-type: none"> • OAS of affected train unit updates mission profile. • OAS of indirectly affected train unit update their mission profile due to track restrictions.

Step 4.3.3 (stop en-route with TA)	TA and OAS informs passengers on unplanned stopping point**.
Step 4.3.4 (stop en-route with TA)	➔ Step 4.6
Step 4.4 (stop en-route)	<ul style="list-style-type: none"> • OAS of affected train unit updates mission profile. • OAS of indirectly affected train unit update their mission profile due to track restrictions.
Step 4.5 (stop en-route)	OAS (and RUS) informs passengers on unplanned stopping point**.
Step 4.6 (stop en-route)	RUS requests RMS to assist evacuation.
Step 4.7 (stop en-route)	Train Unit stops at designated evacuation point.
Step 4.8 (stop en-route)	TAS orders to power down traction current section for the affected evacuation site.
Step 4.9 (stop en-route)	TAS confirms traction current section powered down to EM and that grounding of OLE/short-circuiting of third rail is required***.
Step 4.10 (stop en-route)	Police and EM arrive on-site.
Step 4.11 (stop en-route)	➔ Outcome 2: Train is stopped en-route (not at a platform); Doors closed; Assisted evacuation en-route ordered; Police takes over further handling of the situation; All relevant stakeholders are informed
Step 5	TAS registers incident and assesses situation
Step 6	<p>TAS</p> <ul style="list-style-type: none"> • routes directly affected train unit to suitable evacuation point as defined. • re-routes indirectly affected train units. • reports to RUS of all affected train units, TA, IM and IM (station) and railway security services and other relevant entities.
Step 7	<ul style="list-style-type: none"> • OAS of directly affected train units updates mission • OAS of indirectly affected train units update their mission.

Step 8	OAS (and RUS) inform passengers on (new) stopping point and to prepare for evacuation**.
Step 8.1	TA and OAS informs passengers on (new) stopping point and to disembark**.
Step 9	IM confirms stopping point for affected train unit and usage restrictions in place to authorities.
Step 10	IM (station) initiates crowd management measures for passengers and members of the general public and supports police to evacuate the station.
Step 11	Train Unit stops at designated stopping point (platform).
Step 12	Train Unit opens doors for passengers to leave.
Step 13	OAS (and RUS) inform passengers to leave .the train unit (terminus)**
Step 13.1 (TA on-board)	TA and OAS informs passengers to leave the train unit (terminus)**.
Step 13.2 (TA on-board)	TA confirms to IM and police on-site that all passengers and other personnel have left the train unit.
Step 13.3 (TA on-board)	➔ Outcome 1: Passengers and personnel have left the affected train unit; Police takes over the further handling of the situation; Traffic is halted in the affected area; All relevant stakeholders are informed.
Step 14	Police at platform order passengers to leave the train unit and station.
Step 15	<ul style="list-style-type: none"> • Outcome 1: Passengers and personnel have left the affected train unit; Police takes over the further handling of the situation; Traffic is halted in the affected area; All relevant stakeholders are informed.
Postcondition	<ul style="list-style-type: none"> • Evacuation of train unit at designated evacuation point. • All relevant stakeholders were informed. • Police takes over further handling of the situation. • Train operations are restricted.
Use case notes	* The assumption here is that the input on handling the incident comes from the relevant authorities (police) as an official order of conduct. The original receiver of this information might thus be the IM, the railway undertaking or on-site personnel of the IM or RU, who are forwarding the information to the relevant authorities (police).

	<p>** The exact nature of the information given to passengers/personnel on-board is subject to the respective rules (code of conduct) of the railway undertaking.</p> <p>*** The grounding/short-circuiting is not part of this use case as this is subject to consultation between police and emergency manager</p> <p>**** The assumption here that there are other serviceable train units indirectly involved as well due to re-routing from stations or lines or being put on-hold in parts of the network.</p> <p>It is assumed that the routing request as well as the dedicated concept for handling the incident would be done by the IM (Emergency Control Centre or similar responsible entities) in close cooperation with all relevant stakeholders, mainly the relevant police entities. Other stakeholders subject to the local responsibilities and the organisational set-up could be but are not limited to: Infrastructure Manager (responsible for stations), Railway Undertaking Supervisors of each directly and indirectly affected train units as well as the security organisation of the railway system.</p>
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Table 1: Use case “Handle infrastructure restrictions ordered by authorities - Bomb alarm on train” description

1.48 UC5.1-048: HANDLE STOP TRAIN UNIT DUE TO SECURITY INCIDENTS ON-BOARD – IDENTIFICATION OF PERSONAL DETAILS

1.48.1 UC5.1-048A: Incident reported to RU/IM actors

Use case field	Description	
ID	UC5.1-048A	
Use case name	Handle stop train unit due to security incidents on-board – Reported to RU/IM actors	
Main actor	Trackside Automation System (TAS)	
Other actors	<ul style="list-style-type: none"> • On-board Automation System (OAS) • Relevant contact entity* • Train attendant (TA) • Police officers • Emergency Medical Technicians (EMT) - if requested • Railway Undertaking Supervisor (RUS) • Infrastructure Manager (IM) 	
Use case summary	One or several passengers or personnel are reporting a security incident on-board while the train is enroute (not stationary).	
Applicability	<ul style="list-style-type: none"> • Geographical: European • System level: System GoA3/4 • Operational category: passenger, urban, regional, mainline 	
Main goal	The main goal is to stop the train unit at a designated stopping point (platform) with police and medical first responders (if requested) awaiting the perpetrator/s and treating possible injured persons.	
Preconditions	<ul style="list-style-type: none"> • Train Unit is in service and enroute. • Emergency communication device is linked to relevant contact entity* 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Train Unit stops at designated platform and police officers and EMT are ready at the relevant carriages
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Train is not stopped at the next suitable stopping point and continues mission. • Passenger (or personnel) activates emergency stop request <ul style="list-style-type: none"> -> Train stops en-route -> Passenger may activate emergency door release after stop and detrain themselves leading to further risks while detraining in panic (falling) and possible collision with train units on adjacent tracks.
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	Passenger or TA reports via communication device security incident on-board to relevant contact entity*.

Step 2	Relevant contact entity* registers incident in TAS.
Step 3	TAS assesses situation.
Step 4	TAS identifies suitable stopping point.
Step 5	TAS requests: <ul style="list-style-type: none"> • stop at the suitable stopping point with priority**. • request police officers and emergency medical technicians (if needed) to the stopping point. • reports incident to RUS, IM.
Step 5.1 (TA on-board)	<i>If a train attendant (GoA3) is on-board (step 5.1 to 5.3):</i> TAS requests: <ul style="list-style-type: none"> • stop at the suitable stopping point with priority**. • request police officers and emergency medical technicians (if needed) to the stopping point. • reports incident to TA, RUS, IM.
Step 5.2 (TA on-board)	TA informs passengers (and other personnel) on stop and asked for police support on-board (if available).
Step 5.3 (TA on-board)	➔ Step 7
Step 6	RUS informs passengers on unexpected stop.
Step 7	OAS updates mission profile.
Step 8	Train Unit stops at designated stopping point.
Step 9	➔ Outcome 1: Train Unit stops at designated platform and police officers and emergency medical technicians are ready at the relevant carriages.
Postcondition	<ul style="list-style-type: none"> • Train Unit is stopped and hold at suitable designated stopping point. • Passengers (and personnel) are informed. • Police officers carry out investigation / prosecution. • EMT is attending persons in need.
Use case notes	<p>*Relevant contact entity: The relevant contact entity is subject to the reporting structure defined by the respective railway undertaking. Emergency communication devices might be linked to the train attendant, the operation centre of the RU (here RUS) or dedicated security entities of the RU.</p> <p>**The re-routing to the unexpected stop must contain the note that the train unit should be held at the station for further investigation by authorities.</p> <p>Sources:</p> <ul style="list-style-type: none"> • DBREGIO.8930A30 • 419.2582A02

Table 1: Use case “Handle stop train unit due to security incidents on-board – Reported to RU/IM” description

1.48.2 UC5.1-048B: Incident reported to third actor (police)

Use case field		Description
ID		UC5.1-048B
Use case name		Handle stop train unit due to security incidents on-board – Reported to third actor
Main actor		Trackside Automation System (TAS)
Other actors		<ul style="list-style-type: none"> • On-board Automation System (OAS) • Train attendant (TA) • Police officers • Emergency Medical Technicians (EMT) - if requested • Railway Undertaking Supervisor (RUS) • Infrastructure Manager (IM)
Use case summary		One or several passengers are reporting a security incident on-board while the train is enroute (not stationary).
Applicability		<ul style="list-style-type: none"> • Geographical: European • System level: System GoA3/4 • Operational category: passenger, urban, regional, mainline
Main goal		The main goal is to stop the train unit at a designated stopping point (platform) with police and medical first responders (if requested) awaiting the perpetrator/s and treating possible injured persons.
Preconditions		<ul style="list-style-type: none"> • Train Unit is in service and enroute. • Passenger calls police and call location is traceable.
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Train Unit stops at designated platform and police officers and EMT are ready at the relevant carriages. • Outcome 2: Train Unit cannot be identified unambiguously; the incident is re-registered for all potentially affected trains -> Step 4.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Train is not stopped at the next suitable stopping point and continues mission. • Passenger (or personnel) activates emergency stop request -> Train stops en-route -> Passenger may activate emergency door release after stop and detrain themselves leading to further risks while detraining in panic (falling) and possible collision with train units on adjacent tracks.
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	Passenger reports security incident on-board to third actor (police)*

Step 2	Third actor (police)* reports incident to IM
Step 3	IM identifies train unit and registers incident in TAS
Step 3.1	IM cannot identify train unit unambiguously and registers incident in TAS
Step 3.2	TAS assesses situation and potential train units
Step 3.3	TAS reports to TA (if available), RUS of potentially affected train units
Step 3.4	TAS identifies suitable stopping point for potentially affected train units
Step 3.5	TA/RUS reports/confirms security incident on relevant train unit to TAS
Step 3.5.1	TAS registers separate incident for potentially affected train units after missing confirmation after a certain time
Step 3.5.2	➔ Outcome 2: Train Unit cannot be identified unambiguously; the incident is re-registered for all potentially affected trains -> Step 4
Step 3.6	• Step 6
Step 4	TAS assesses situation
Step 5	TAS identifies suitable stopping point
Step 6	TAS requests <ul style="list-style-type: none"> • stop at the suitable stopping point with priority** • reports to stopping point to police officers and emergency medical technicians (if needed) • suitable stopping point to OAS • reports incident to RUS, IM (for acknowledgement)
Step 6.1 (TA on-board)	<i>If a train attendant (GoA3) is on-board (step 6.1 to 6.3):</i> TAS requests <ul style="list-style-type: none"> • stop at the suitable stopping point with priority** • reports to stopping point to police officers and emergency medical technicians (if needed) • suitable stopping point to OAS • reports incident to TA, RUS, IM (for acknowledgement)
Step 6.2 (TA on-board)	TA informs passengers (and other personnel) on unexpected stop
Step 6.3	➔ Step 7

	Step 7	RUS informs passengers on unexpected stop
	Step 8	OAS updates mission profile
	Step 9	Train Unit stops at designated stopping point
	Step 10	➔ Outcome 1: Train Unit stops at designated platform and police officers and EMT are ready at the relevant carriages
Postcondition		<ul style="list-style-type: none"> • Train Unit is stopped and hold at suitable designated stopping point. • Passengers (and personnel) are informed. • Police officers carry out investigation / prosecution. • EMT is attending persons in need.
Use case notes		<p>*Third actor (police) here refers to the overall entity where members of the general public can call in case of an emergency. The exact entity responsible for emergencies might differ between countries or areas of responsibilities. The third actor might also forward the incident to other entities (e.g., police entities) responsible for railway operations.</p> <p>**The re-routing to the unexpected stop must contain the note that the train unit should be held at the station for further investigation by authorities.</p> <p>Sources:</p> <ul style="list-style-type: none"> • DBREGIO.8930A30 • 419.2582A02

Table 2: Use case “Handle stop train unit due to security incidents on-board – Reported to third actors” description

1.49 UC5.1-049: HANDLE OVERCROWDED TRAIN UNIT

Use case field	Description	
ID	UC5.1-049	
Use case name	Handle overcrowded train unit	
Main actor	Onboard Automation System (PER, APM)	
Other actors	<ul style="list-style-type: none"> • Police officer(s) • Railway Undertaking Supervisor 	
Use case summary	<p>Legal Overcrowding: OAS must inform trackside of a possible impact on dwell time. supervise the adapted dwell times of the Journey Profile.</p> <p>Illegal Overcrowding: Passengers are requested to leave the train until the train (and each vehicle) has an occupation smaller than maximum occupation. If not enough passengers leave the train, the police officer(s) is/are called to clear the train (i.e. reduce the number of people inside). If the police officer(s) did not succeed, the train is cancelled.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA3/4 • Operational category: passenger, urban, regional, mainline 	
Main goal	Prevent an unsafe journey due to an overcrowded train.	
Preconditions	Train is in station. Automatic driving in GoA3 or 4 is activated. Too many passengers (by number or weight) are in the train or certain vehicles. In the following we use the term “area” for train in total or individual vehicles.	
Termination outcome	Successful outcomes	Outcome 1: Several passengers leave the overcrowded area, resulting in an occupation smaller than the maximal occupation. The train continues its journey (probably with a delay).
	Unsuccessful outcomes	Outcome 2: Not enough passengers leave the overcrowded area. The train is cancelled.
Condition affecting termination outcome	Outcome 2	Train cannot run because of overcrowding. Police officer(s) was/were called. Train is cancelled. TAS is informed about cancellation of the train. Train must be evacuated. TAS decides about the next operation.
Use case scenario	Step 1	OAS detects an overcrowded area by weight or number of passengers.
	Step 1.1.1	If the overcrowding is legal: Train may run with legal overcrowding. OAS informs TAS about lower speed and increased dwell time. OAS makes Announcement (text and audio) that there are free seats in other coaches.
	Step 1.1.2	OAS periodical announces (text and audio) that an area is overcrowded, and some passengers must leave the area until it is not overcrowded anymore. If there is free space

	in other areas of the train: OAS announces “There is free space in vehicles ‘XY’”.
Step 1.1.3	Enough passengers left the area.
Step 1.2.1	Overcrowding is illegal. IF not enough passengers left the area, go to Step 1.2.5
Step 1.2.2	Train may depart according to: X2Rail-4 13.6.6 UC “Door closing (passenger train)” X2Rail-4 13.5.2 UC “Supervise departure of a passenger train”
Step 1.2.3	OAS sends new estimated arrival time at next timing point to TAS. TAS may send new timetable if necessary (if delay was generated by overcrowded situation).
Step 1.2.4	Use case ended successfully with Outcome 1.
Step 1.2.5	IF we are driving in GoA4 OR there is no staff at the platform: go to Step 2
Step 1.2.6	Staff tries to convince passengers to leave the area.
Step 1.2.7	IF enough passengers left the area: go to Step 1.2.2
Step 2	OAS still detects an overcrowding after some time. OAS reports incident to TAS.
Step 3	OAS makes a last announcement (text and audio) to leave the area.
Step 4	Staff (if involved) or TAS activates police officer(s) to ensure that some passengers leave the train.
Step 5	Police officer(s) ensure(s) that passengers leave the area.
Step 5.1	IF enough passengers leave the area: go to Step 1.2.2
Step 6	Still too many passengers in area: Police officer(s) and/or operation manager decide(s) to cancel the train and inform TAS that the train has to be cancelled. TAS informs OAS that train is cancelled.
Step 7	OAS announces (text and audio) that the train is cancelled.
Step 8	Evacuation of train by police officer(s) and/or Railway Undertaking Supervisor. If train is empty, train may be driven away from platform.

	Step 9	TAS may send a new mission/journey Profile. Train continues with new task. Use case finished with Outcome 2.
Postcondition	Timetable is updated and vehicle planning is updated.	
Use case notes	This use case is required only for GoA3/4. In GoA2 it is the task of the driver to handle an overcrowded train. Therefor out of scope.	

Table 1: Use case “Handle overcrowded train unit” description

**1.50 UC5.1-050: HANDLE PANIC SITUATION OR RIOT IN THE TRAIN - IN STATION
DETECTED BY ON-BOARD SYSTEMS**

Use case field	Description	
ID	UC5.1-050	
Use case name	Handle panic situation or riot in the train - in station detected by on-board systems	
Main actor	On-board automation systems (OAS)	
Other actors	<ul style="list-style-type: none"> • Trackside Automation System (TAS) • Train Attendant (TA) • Railway Undertaking Supervisor (RUS) • Railway Security Entity • Police Entities (responsible to supervise rail operations) • Certified First Responder (CFR) 	
Use case summary	<p>A sudden hazardous overcrowded situation inside a train unit (and/or at the platform next to the train unit) is detected by on-board means. No previous overcrowded report was filed and as such no crowd management measures were initiated as the situation quickly developed.</p> <p>The overcrowded situation can be described as hazardous due to the risk of a stampede with persons suffocating or being crushed.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European • System level: System GoA3/4 • Operational category: passenger, urban, regional, mainline 	
Main goal	The main goal is to hold the train unit at the platform and request medical aid for injured passengers. Crowd management measures need to be insured both inside the train as well as on the platform to disperse the crowd and facilitate that medical responders can effectively locate and reach the passengers.	
Preconditions	<ul style="list-style-type: none"> • Train unit is standing at a platform. • Sensors inside train unit are capable of assessing overcrowded situations. • Passengers/personnel require medical assistance 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Train Unit mission is cancelled; Train Unit is hold; Crowd Management measures were implemented; Safety and Security entities are requested
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Train Unit departs (if doors are released and are not obstructed by crowds)
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	OAS detects hazardous level of crowd density inside train unit.

Step 2	OAS assesses situation.
Step 3	<p>OAS</p> <ul style="list-style-type: none"> • Commands to hold doors open (and avoid train departure if doors can be closed). • Utilises crowd management measures to disperse passengers from train unit. • stops/halts the mission. • Request for medical aid (Certified First responder) on-board via communication on-board. • Reports to TAS.
Step 3.1 (GoA3)	<ul style="list-style-type: none"> • Commands to hold doors open (and avoid train departure if doors can be closed). • Utilises crowd management measures to disperse passengers from train unit. • stops/halts the mission. • Request for medical aid (Certified First responder) on-board via communication on-board. • Reports to TAS. • Reports to TA.
Step 3.2 (GoA3)	TA assesses situation and initiates crowd management measures according to rule book (announcements).
Step 3.3 (GoA3)	<ul style="list-style-type: none"> • Step 4.
Step 4	TAS assesses situation.
Step 5	<p>TAS requests</p> <ul style="list-style-type: none"> • to hold affected train units at station (mission cancelled/halted). • requests police officers, emergency medical technicians (if needed) and railway security (if available). • request crowd management measures to RUS, IM (station). • reports incident to RUS, IM.
Step 6	OAS updates mission profile.
Step 7	IM (station) calls for passengers to leave overcrowded areas immediately and vacate for police and medical responders.
Step 8	<p>→ Outcome 1: Train Unit mission is cancelled; Train Unit is hold; Crowd Management measures were implemented; Safety and Security entities are requested.</p>
Postcondition	<ul style="list-style-type: none"> • Train Unit remains standing at the platform (departure halted). • Safety and security entities have been requested.
Use case notes	*Third actor (police) here refers to the overall entity where members of the general public can call in case of an emergency. The exact entity

	<p>responsible for emergencies might differ between countries or areas of responsibilities. The third actor might also forward the incident to other entities (e.g., police entities) responsible for railway operations.</p> <p>In the course of the use case after the incident is reported to the RUS. The RUS or other stakeholders authorised by the RUS (e.g., railway security) may use remote supervision technologies (e.g. CCTV, audio) to assess and monitor the situation, if devices area available and depending on the technology used. This might differ between each railway undertaking or vehicle in their fleet.</p> <p>Sources:</p> <ul style="list-style-type: none"> • 513.2020A01 Auslastungsgrenzen und Handhabung von Überbesetzung
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Table 1: Use case “Handle panic situation or riot in the train - in station detected by on-board systems” description

1.51 UC5.1-051: HANDLE PANIC SITUATION (STAMPEDE) OR RIOT IN THE TRAIN - IN STATION DETECTED BY EXTERNAL ACTOR

1.51.1 UC5.1-051A: External Actor is Passenger

Use case field	Description	
ID	UC5.1-51A	
Use case name	Panic situation or riot in the train - in station detected by external actor	
Main actor	Trackside Automation System (TAS)	
Other actors	<ul style="list-style-type: none"> • On-board Automation System (OAS) • Train attendant (TA) • Third Actor (police)* • Police officer • Railway Security Officer • Emergency medical technicians (EMT) • Railway Undertaking Supervisor (RUS) • Infrastructure Manager (IM) 	
Use case summary	<p>One or several passengers are reporting a hazardous overcrowded situation inside a train unit and/or at the platform next to the train unit. No previous overcrowded report was filed and as such no crowd management measures were initiated as the situation quickly developed.</p> <p>The overcrowded situation can be described as hazardous due to the risk of a stampede with persons suffocating or being crushed.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European • System level: System GoA3/4 • Operational category: passenger, urban, regional, mainline 	
Main goal	The main goal is to hold the train unit at the platform and request medical aid for injured passengers. Crowd management measures need to be insured both inside the train as well as on the platform to disperse the crowd and facilitate that medical responders can effectively locate and reach the passengers.	
Preconditions	<ul style="list-style-type: none"> • Train Unit is standing at a platform. • Mobile network coverage is available, and passenger calls the police and the call location is traceable. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Train Unit mission is cancelled; Train Unit is hold; Crowd Management measures were implemented; Safety and Security entities are requested.
	Unsuccessful outcomes	<ul style="list-style-type: none"> ➔ Outcome 2: The Train Unit mission is not on-hold; Train Unit left station.
Condition affecting termination outcome	Outcome 2	<ul style="list-style-type: none"> • Train Unit departed prior to registration of incident in the TAS.

Use case scenario	Step 1	Passenger reports security incident on-board to third actor (police)*.
	Step 2	Third actor (police)* reports incident to IM and commands train unit to stop train unit/s.
	Step 3	IM identifies train unit and registers incident in TAS. Otherwise, proceed to Step 4.
	Step 3.1	TAS assesses the situation.
	Step 3.1.1	TAS identifies that train unit has already departed from station. → Outcome 2: The Train Unit mission is not on-hold; Train Unit left station.
	Step 3.2	TAS requests: <ul style="list-style-type: none"> • To hold train unit at station (usage restrictions). • Requests police officers, emergency medical technicians (if needed) and railway security officers (if available). • Reports incident to RUS, IM.
	Step 3.4	OAS updates mission profile.
	Step 3.5	OAS utilises crowd management means to disperse passengers from train.
	Step 3.6	IM (station) calls for passengers to leave overcrowded areas immediately and vacate for police officers and emergency medical technicians.
	Step 3.7	TA/RUS confirm unaffected train units to TAS.
	Step 3.8	TAS lifts usage restrictions for unaffected train units.
	Step 3.9	<ul style="list-style-type: none"> • Outcome 1: Train Unit mission is cancelled; Train Unit is hold; Crowd Management measures were implemented; Safety and Security entities are requested.
	Step 4	IM cannot identify train unit unambiguously and registers incident in TAS.
Step 5	TAS assesses the situation.	
Step 6	TAS requests: <ul style="list-style-type: none"> • To hold affected train units at station (mission cancelled). • Requests police officers, emergency medical technicians (if needed) and railway security officers (if available). • Reports incident to RUS, IM. 	

	Step 7	OAS updates mission profile
	Step 8	OAS utilises crowd management means to disperse passengers from train
	Step 9	IM (station) calls for passengers to leave overcrowded areas immediately and vacate for police officers and emergency medical technicians.
	Step 10	→ Outcome 1: Train Unit mission is cancelled; Train Unit is hold; Crowd Management measures were implemented; Safety and Security entities are requested.
Postcondition		<ul style="list-style-type: none"> • Train Unit remains standing at the platform (departure halted). • Safety and security entities have been requested.
Use case notes		<p>*Third actor (police) here refers to the overall entity where members of the general public can call in case of an emergency. The exact entity responsible for emergencies might differ between countries or areas of responsibilities. The third actor might also forward the incident to other entities (e.g., police entities) responsible for railway operations.</p> <p>Sources:</p> <ul style="list-style-type: none"> • 513.2020A01 Auslastungsgrenzen und Handhabung von Überbesetzung

Table 1: Use case “Panic situation (stampede) or riot in the train - in station detected by external actor – Passenger” description

1.51.2 UC5.1-051B: External Actor is Train Attendant

Use case field		Description
ID		UC5.1-051B
Use case name		Panic situation (stampede) or riot in the train - in station detected by external actor
Main actor		Trackside Automation System (TAS)
Other actors		<ul style="list-style-type: none"> • On-board Automation System (OAS) • Train attendant (TA) • Police officer • Railway Security Officer • Emergency medical technicians (EMT) • Railway Undertaking Supervisor (RUS) • Infrastructure Manager (IM) • Infrastructure Manager (IM station)
Use case summary		<p>One or several passengers are reporting a hazardous overcrowded situation inside a train unit and/or at the platform next to the train unit. No previous overcrowded report was filed and as such no crowd management measures were initiated as the situation quickly developed.</p> <p>The overcrowded situation can be described as hazardous due to the risk of a stampede with persons suffocating or being crushed.</p>
Applicability		<ul style="list-style-type: none"> • Geographical: European • System level: System GoA3 • Operational category: passenger, urban, regional, mainline
Main goal		The main goal is to hold the train unit at the platform and request medical aid for injured passengers. Crowd management measures need to be insured both inside the train as well as on the platform to disperse the crowd and facilitate that medical responders can effectively locate and reach the passengers.
Preconditions		<ul style="list-style-type: none"> • Train Unit is standing at a platform. • Passenger calls police and call location is traceable. • TA has already implemented crowd steering measures.
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Train Unit mission is cancelled; Train Unit is hold; Crowd Management measures were implemented; Safety and Security entities are requested.
	Unsuccessful outcomes	<ul style="list-style-type: none"> ➔ Outcome 2: The Train Unit mission is not on-hold; Train Unit left station.
Condition affecting termination outcome	Outcome 2	<ul style="list-style-type: none"> • Train Unit departed prior to registration of incident in the TAS.
Use case scenario	Step 1	TA reports hazardous overcrowded event in train unit to IM.

	Step 2	IM identifies train unit and registers incident in TAS.
	Step 3	TAS assesses situation.
	Step 3.1.1	TAS identifies that train unit has already departed from station. → Outcome 2: The Train Unit mission is not on-hold; Train Unit left station.
	Step 4	TAS requests: <ul style="list-style-type: none"> • To hold affected train units at station (mission cancelled). • Requests police officers, emergency medical technicians (if needed) and railway security officers (if available). • Railway security (if available). • Reports incident to RUS, IM, IM (station).
	Step 5	OAS updates mission profile.
	Step 6	OAS utilises crowd management means to disperse passengers from train.
	Step 7	IM (station) calls for passengers to leave overcrowded areas immediately and vacate for police officers and emergency medical technicians.
	Step 8	→ Outcome 1: Train Unit mission is cancelled; Train Unit is hold; Crowd Management measures were implemented; Safety and Security entities are requested.
Postcondition		<ul style="list-style-type: none"> • Train Unit remains standing at the platform (departure halted) • Safety and security entities have been requested
Use case notes		Sources: <ul style="list-style-type: none"> • 513.2020A01 Auslastungsgrenzen und Handhabung von Überbesetzung

Table 2: Use case “Panic situation (stampede) or riot in the train - in station detected by external actor – Train Attendant” description

1.52 UC5.1-052: HANDLE PANIC SITUATION (STAMPEDE) OR RIOT IN THE TRAIN - DURING TRAIN UNIT RUN DETECTED BY ON-BOARD SYSTEMS

Use case field	Description	
ID	UC5.1-052	
Use case name	Handle panic situation (stampede) or riot in the train - during train unit run detected by on-board systems	
Main actor	On-board Automation System (OAS)	
Other actors	<ul style="list-style-type: none"> • Trackside Automation System (TAS) • Train Attendant (TA) • Railway Undertaking Supervisor (RUS) • Railway Security Officers • Police Officers (responsible to supervise rail operations) • Emergency Medical Technicians (EMT) • Passenger 	
Use case summary	<p>Within a crowded train unit, a situation develops where passengers (and personnel) are concentrating beyond a safe level leading to unhealthy conditions and persons requiring medical aid.</p> <p>The overcrowded situation can be described as hazardous due to the risk of a stampede with persons suffocating or being crushed.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European • System level: System GoA3/4 • Operational category: passenger, urban, regional, mainline 	
Main goal	The main goal is to stop the train unit at the next station and request medical aid for injured passengers. Crowd management measures need to be insured both inside the train to disperse passengers.	
Preconditions	<ul style="list-style-type: none"> • Train Unit is en-route with high occupancy rate (below overcrowded limit). • Sensors inside train unit are capable of assessing overcrowded situations. • Passengers/personnel require medical assistance. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Train Unit is stopping at the next suitable stopping point; Train Unit is hold; Crowd Management measures were implemented; Safety and Security entities are requested.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Train is not stopped at the next suitable stopping point and continues mission. • Passenger (or personnel) activates emergency stop request -> Train stops en-route -> Passenger may activate emergency door release after stop and detrain themselves leading to further risks while detraining in panic (falling) and possible collision with train units on adjacent tracks.

Condition affecting termination outcome	Outcome 1	<ul style="list-style-type: none"> • Passenger (or personnel) activates emergency stop request -> see unsuccessful outcomes. • Route / tracks to suitable stopping point are (still) occupied. • Suitable stopping point for these situations is a platform at a station to facilitate a quick detrainment as opposed to evacuation en-route.
Use case scenario	Step 1	OAS detects hazardous level of crowd density inside part of the train unit
	Step 2	OAS assesses situation.
	Step 3	<p>OAS</p> <ul style="list-style-type: none"> • Utilises crowd management measures to disperse passengers inside the train unit (reverse passenger flow) • Request medical aid via communication on-board • Identifies the next suitable stopping point (next station) • Reports to TAS
	Step 3.1 (TA on-board)	<p>OAS</p> <ul style="list-style-type: none"> • Utilises crowd management measures to disperse passengers inside the train unit (reverse passenger flow) • Identifies the next suitable stopping point (next station) and reports to TAS • Reports to TAS • Reports to TA <p><i>The steps 3.1 to 3.5 refers to the situation that a train attendant is on-board</i></p>
	Step 3.2 (TA on-board)	TA assesses the situation to identify the cause and extend of the hazardous situation (if possible).
	Step 3.3 (TA on-board)	TA uses crowd management measures to disperse passengers (announcement).
	Step 3.4 (TA on-board)	TA request medical assistance at the IM.
	Step 3.5 (TA on-board)	Proceed to Step 4.
	Step 4	TAS assesses situation.
	Step 5	<p>TAS requests.</p> <ul style="list-style-type: none"> • Changes mission to stop at the next suitable station

		<ul style="list-style-type: none"> requests police officers, emergency medical technicians (if needed) and railway security officers (if available) reports incident to RUS, IM, IM (station)
	Step 5.1 (TA on-board)	TAS requests <ul style="list-style-type: none"> Changes mission to stop at next suitable stopping point. requests police officers, emergency medical technicians (if needed) and railway security officers (if available). reports suitable stopping point to TA. reports incident to RUS, IM, IM (station).
	Step 6	OAS updates mission profile
	Step 7	OAS announces stopping point to passengers
	Step 7.1 (TA on-board)	TA announces stopping point to passengers
	Step 8	Train Unit stops at next suitable stopping point (station)
	Step 9	Train Unit opens doors to disperse crowd and enable EMT to reach injured passengers/personnel
	Step 10	<ul style="list-style-type: none"> Outcome 1: Train Unit stops at next station; Train Unit is hold; Crowd Management measures were implemented inside the train unit; Safety and Security entities are requested.
Postcondition		<ul style="list-style-type: none"> Train Unit remains standing at the platform (departure halted) Safety and security entities have been requested
Use case notes	Possible scenarios where the situation describes in this use can occur: <ul style="list-style-type: none"> Large-scale event (e.g., sport events) Security incidents in one part of the train Bottleneck situations where passengers concentrate in only one part of the train unit due to blocked passage (by persons, by luggage) <p>The crowd management measures implemented inside the train unit may not lead to a noticeable relieve of the situation. Side effects or even antagonising effects like bottlenecks in other parts.</p>	

Table 1: Use case “Handle panic situation (stampede) or riot in the train - during train unit run detected by on-board systems” description

1.53 UC5.1-053: HANDLE PANIC SITUATION (STAMPEDE) OR RIOT IN THE TRAIN - DURING TRAIN UNIT RUN DETECTED BY EXTERNAL ACTOR

Use case field	Description	
ID	UC5.1-053	
Use case name	Handle panic situation (stampede) or riot in the train - during train unit run detected by external actor	
Main actor	Trackside Automation System (TAS)	
Other actors	<ul style="list-style-type: none"> • On-board Automation System (OAS) • Train attendant (TA) • Third Actor (police/RUS)* • Police Officer • Railway Security Officer • Emergency Medical Technicians (EMT) • Railway Undertaking Supervisor (RUS) • Infrastructure Manager (IM) • Passenger 	
Use case summary	<p>Within a crowded train unit, a situation develops where passengers (and personnel) are concentrating beyond a safe level leading to unhealthy conditions and persons requiring medical aid. One or several passengers are reporting a security incident on-board while the train is enroute (not stationary).</p> <p>The overcrowded situation can be described as hazardous due to the risk of a stampede with persons suffocating or being crushed.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European • System level: System GoA3/4 • Operational category: passenger, urban, regional, mainline 	
Main goal	The main goal is to disperse the crowd on-board the train unit and to stop the train unit at the next possible stopping point (platform) with medical first responders (if requested) awaiting treating possible injured persons and/or police prosecuting any offenders, investigating the cause of the stampede.	
Preconditions	<ul style="list-style-type: none"> • Train Unit is in service and enroute. • Mobile network coverage is available, and passenger calls the police, and the call location is traceable. • Passengers/personnel require medical assistance. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Train Unit stops at designated platform medical first responders and police officers are ready at the relevant carriages. • Outcome 2: Train Unit cannot be identified unambiguously; the incident is re-registered for all potentially affected trains à Step 4.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Train is not stopped at the next suitable stopping point and continues mission. • Passenger (or personnel) activates emergency stop request <ul style="list-style-type: none"> -> Train stops en-route -> Passenger may activate emergency door release

		<p>after stop and detrain themselves leading to further risks while detraining in panic (falling) and possible collision with train units on adjacent tracks.</p> <ul style="list-style-type: none"> Wrong train unit is identified based on input from actors.
Condition affecting termination outcome	Outcome 3	<ul style="list-style-type: none"> Passenger (or personnel) activates emergency stop request -> see unsuccessful outcomes. Route / tracks to suitable stopping point are (still) occupied. Suitable stopping point for these situations is a platform at a station to facilitate a quick detrainment as opposed to evacuation en-route. Wrong train unit is identified based on input from actors.
Use case scenario	Step 1	Passenger reports security incident on-board to third actor (police/RUS)*.
	Step 2	Third actor (police/RUS)* reports incident to IM and commands to stop the train unit at the next station or safe stopping point.
	Step 3	IM identifies train unit and registers incident in TAS.
	Step 3.1	IM cannot identify train unit unambiguously and registers incident in TAS.
	Step 3.2	TAS assesses situation and identify potential train units.
	Step 3.3	TAS reports to TA (if available), RUS of potentially affected train units.
	Step 3.4	TAS identifies suitable stopping point for potentially affected train units.
	Step 3.5	TA/RUS reports/confirms security incident on relevant train unit to TAS.
	Step 3.5.1	TAS registers separate incident for potentially affected train units after missing confirmation after a certain time.
	Step 3.5.2	➔ Outcome 2: Train Unit cannot be identified unambiguously; the incident is re-registered for all potentially affected trains à Step 4.
	Step 3.6	<ul style="list-style-type: none"> Step 6
	Step 4	TAS assesses situation.
	Step 5	TAS identifies suitable stopping point.
	Step 6	<p>TAS requests</p> <ul style="list-style-type: none"> Stop at the suitable stopping point with priority. Reports to stopping point to police officers and EMT and railway security officers (if available).

		<ul style="list-style-type: none"> • Reports incident and suitable stopping point to OAS. • Reports incident to RUS, IM (and TA if available) (for acknowledgement).
	Step 7	<ul style="list-style-type: none"> • RUS/TA calls on passengers to disperse inside the train unit and leave for less crowded carriages and pave way for suffocating persons. • OAS Utilises crowd management measures to disperse passengers inside train unit (reverse passenger flow) • OAS Request medical aid via communication on-board
	Step 8	RUS/TA request passengers for medical support or support in first aid.
	Step 9	RUS/TA informs passengers (and other personnel) on stopping point.
	Step 10	OAS updates mission profile.
	Step 11	OAS announces stopping point to passengers.
	Step 12	Train Unit stops at designated suitable stopping point (station).
	Step 13	Train Unit opens doors to disperse crowd and enable EMT to reach injured passengers/personnel.
	Step 14	➔ Outcome 1: Train Unit stops at designated platform medical first responders and police officers are ready at the relevant carriages.
Postcondition		<ul style="list-style-type: none"> • Train Unit is stopped at suitable designated stopping point. • Safety and security entities have been requested.
Use case notes	<p>*Third actor (police/RUS) here refers to the overall entity where members of the general public can call in case of an emergency. The third actor here might be a police entity receiving a call from a mobile phone by a passenger, the railway undertaking service centre or security entity receiving an emergency request from passengers via emergency call device on-board a train unit or other actors passengers/personnel may call. The exact entity responsible for emergencies might differ between countries or areas of responsibilities. The third actor might also forward the incident to other entities (e.g., police entities) responsible for railway operations.</p> <p>Possible scenarios where the situation describes in this use can occur:</p> <ul style="list-style-type: none"> • Large-scale event (e.g., sport events) • Security incidents in one part of the train • Bottleneck situations where passengers concentrate in only one part of the train unit due to blocked passage (by persons, by luggage) <p>The crowd management measures implemented inside the train unit may not lead to a noticeable relieve of the situation. Side effects or even antagonising effects like bottlenecks in other parts.</p>	

Table 1: Use case “Handle panic situation (stampede) or riot in the train - during train unit run detected by external actor” description

1.54 UC5.1-054: EMERGENCY ON TRAIN – IN STATION

Use case field	Description
ID	UC5.1-054
Use case name	Emergency on train - In station
Main actor	Passenger
<i>Other actors</i>	<ul style="list-style-type: none"> • Traveller 1, RU-Supervisor, Operations Manager, Incident manager • Rescue Team: Health assistance staff, Security officer, potentially police officer • HMI components: Passenger Alarm System, On-board Multimedia and Telematic Subsystem
Use case summary	<p>A passenger initiates an emergency by pressing the button on the Passenger Alarm System. The scenario assumes a worst-case situation where a passenger on the platform becomes trapped in the closed train doors, possibly due to an item such as a purse obstructing the doors. This use-case allows all relevant parties to swiftly engage and respond with the urgency demanded by the situation.</p> <p>Note: the use-case intends to refine §13.9.14 X2Rail-4's SRS.</p>
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: On-board Automation System (OAS), Incident Solving Management, Track Side Automation System (TAS) • Operational category: All
Main goal	<p>This use-case aims to illustrate the scenario in which a passenger receives remote assistance from human operators on a train that is primarily autonomous. The description will cover how the train is expected to operate before, during, and after the point at which human intervention becomes necessary.</p> <p>The focus of this use-case is to depict a multifaceted responsibility takeover. Specifically, it addresses a situation occurring at the critical juncture where the train and platform interface, thereby involving both the Railway Undertaker and the Operations Manager. To facilitate efficient response times, the communication system will be designed to ensure that the quickest available responder attends to the passenger's needs, while other operators are strategically positioned for support.</p>
Preconditions	<p>The platform:</p> <ul style="list-style-type: none"> • Is not equipped with Platform Screen Doors. <p>The train:</p> <ul style="list-style-type: none"> • Is stopped along a platform or. • Is leaving this platform: a part of it is still in front of the platform or its speed has not reached V_PlatformLeft yet. See DB-NRS-70 for a train without door in front of the platform or with a speed > V_PlatformLeft.

		<ul style="list-style-type: none"> Has not identified that a passenger is trapped in a locked door, e.g. by some bag or purse: if so, it would be another scenario.
Termination outcome	Successful outcomes	<p>The emergency is assessed. Rescue is on its way, if necessary.</p> <p>The train is stopped at platform, applying Parking Brakes, doors are open, unlocked or locked according to the need set by the use-case.</p>
	Unsuccessful outcomes	<p>The emergency is not assessed, or rescue is not on its way.</p> <p>The train has not stopped in due time.</p> <p>Doors are:</p> <ul style="list-style-type: none"> Closed while safety commands to open them. Locked while safety would require passenger to decide whether opening is right. Unlocked or opened while the appropriate crowd management would be to confine the people in the train compartment.
Condition affecting termination outcome	Outcome 2	N/A
	Step 1	Passenger 1: pushes the emergency button of a door's passenger alarm system.
	Step 2	<p>Train: The train assesses its speed and position towards the platform. By definition of this use-case, it is either stopped at the platform, or leaving the platform.</p> <p>If the train is leaving the platform, jump to step 3.1 and 3.2 in parallel.</p> <p>If the train is stopped at the platform, jump to step 3.2 only.</p>
	Step 3.1	<p>[The train is leaving the platform]</p> <p>Train: The train performs an emergency braking intervention.</p> <p>Jump to 3.2.1 and 3.3 in parallel.</p>
	Step 3.2.1	Train: The train suspends its journey execution until the incident is acknowledged as solved by a controlling remote driver. This aspect is evaluated while authorizing the departure of autonomous train ([SRS X2Rail-4] v0.3, §13.4.6).
	Step 3.2.2	<p>[The train is immobilized]</p> <p>Train:</p>

		The train unlocks all doors in front of the platform, but for the door where the emergency has been notified. It leaves all other doors not in front of the platform locked.
	Step 3.2.3	Train, Door for which the emergency has been notified: If not in front of the platform, the door remains locked. If in front of the platform, it is unlocked and opened after a warning message is issued "Due to emergency, door will open right away".
	Step 3.3	The RU supervisor is notified (alarm) of a passenger alarm request. He/she is asked by its HMI to take the communication with the passengers. At the same time, the Operations Manager is notified (alarm) of a passenger requesting for assistance in a train at platform.
	Step 3.4	The operations manager is notified who the RU Supervisor in charge is. He/she may decide to listen to the call between RU Supervisor. He/she can be invited in the call by the RU supervisor at any time. The RU Supervisor is sees on his/her HMI the operations manager in charge.
	Step 4.0	[The RU Supervisor has taken the call] The RU Supervisors asks actively about the situation. He/she sees whether an operation manager is already listening. He/she might invite the responsible Operations Manager to listen at any time. The Operations manager then comes in 'listening only'. The traveller describes a traveller trapped by his/her purse in the door, dragged on the platform. The traveller's purse has been freed by the door opening but he/she has an arm and a leg between train and platform, and the passengers and travellers around do not manage to move the person without causing tremendous pain in his/her back. The traveller is comfortable when he/she is not manipulated. Once the situation is first cleared, the one in charge may decide to give each other the ability to speak with the passenger or isolate themselves in a bilateral call. The following steps 5.x and 6.x may happen in parallel.
	Step 5.0	RU-Supervisor:

		<p>The RU-Supervisor chooses to qualify the incident as 'person trapped by departing train'. An Incident Manager is named, who will dedicate to coordinating the incident.</p> <p>The incident creation calls automatically the local rescue team: police, rescue staff.</p>
	Step 5.1	<p>Incident Manager:</p> <p>The Incident Manager is now in charge, coordinating the rescue team and station assets remotely (e.g., remotely opening gates). Jump to 7.x for his/her actions (parallel to 6.x for the operations manager).</p>
	Step 6.0	<p>Operations manager:</p> <p>The operations manager starts rescheduling trains – also following trains on the opposite platform.</p>
	Step 7.0	<p>RU-Supervisor:</p> <p>The RU Supervisor informs all compartment passengers about the incident. He/she informs that the train cannot depart again before the trapped passenger is taken care of. He/she asks to stay in the train.</p>
	Step 7.1	<p>Rescue Team:</p> <p>The rescue team, now on site, manages to free the trapped traveller while minimizing the risk of further injuries to his/her back.</p>
	Step 7.2	<p>Rescue Team:</p> <p>The rescue team notifies the incident manager that Passenger 2 is safe on the platform. The train may depart.</p>
	Step 7.3	<p>Incident Manager:</p> <p>The incident manager acknowledges the incident solving on the train. The operations manager is automatically notified. The RU-Supervisor is automatically notified.</p> <p>(This aspect will be evaluated while authorizing the departure of autonomous train ([SRS X2Rail-4] v0.3, §13.4.6).</p>
	Step 7.4	<p>RU-Supervisor:</p> <p>The incident manager informs passengers that the incident no longer delays the train, and doors will close soon.</p>
	Step 7.5	<p>RU-Manager:</p>

		The RU Supervisor engages ATO.
Postcondition	The train resumes mission. Care of injured passengers may require use-case DB-NRS-81 to follow: The incident manager still assists the rescue team, e.g., passing the gates.	
Use case notes	<p>UC5.1-057, UC5.1-054, UC5.1-055, UC5.1-056 are related with each other.</p> <p>Also related to [SRS X2Rail-4] Baseline 0.1, Chapter 13.9.14 Use of Passenger Alarm in station and Chapter 13.9.15 Use of Passenger Alarm when train is starting (train still along platform)</p>	

Table 1: Use case “Emergency on train - in station” description

1.55 UC5.1-055: PERSON IN PASSENGER CABIN NEEDING MEDICAL ASSISTANCE, DETECTED BY ACTOR

Use case field	Description	
ID	UC5.1-055	
Use case name	Person in passenger cabin needing medical assistance, detected by actor	
Main actor	Passengers 1 (via Passenger Alarm System)	
Other actors	<ul style="list-style-type: none"> • Passenger 2 • Passenger 3 (with medical skills) • RU Supervisor (RUS) • Infrastructure incident manager (IIM) • Remote Emergency Medical Technician (REMT) • Operations Manager (OM) 	
Use case summary	<p>A passenger has condition that needs urgent medical assistance.</p> <p>People in the train are instructed remotely how to perform first aid gestures. The most efficient place for emergency health care is coordinated – 2 stations after the call.</p> <p>The train skips a station and drives toward the rescue area with sustained speed.</p> <p>Passenger 1 is off-boarded. Further assistance is given to passenger 1 on the platform.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: On-board Automation System (OAS), Incident Solving Management, Track Side Automation System (TAS) • Operational category: All 	
Main goal	This use-case intends to demonstrate the means IM and RU have to advice passengers in a stress situation, and those in traffic management / train driving.	
Preconditions	<p>A Passenger train has left platform long ago enough / drives fast enough (V_PlatformLeft) to avoid use case 'UC5.1-054 Emergency on train – in station'. It runs GoA4.</p> <p>Passenger 1 suffers a health problem. Passenger 2 witnesses it.</p>	
Termination outcome	Successful outcomes	<p>Passenger 1 overcomes illness.</p> <p>The train resumes mission with a reasonable delay</p>
	Unsuccessful outcomes	<p>Passenger 1's health suffers heavier damages or</p> <p>Passenger 2 (or other, according to skills) could not until professional assistance arrived.</p>

		<p>Passenger 2 and others perceived an unprofessional, weak support during their trip. This is considered a failure because it generates unnecessary psychological last, even if unnoticed.</p> <p>The train resumes mission with a delay beyond necessary.</p>
Condition affecting termination outcome	Outcome 2	N/A
	Step 1	<p>Passenger 2: Passenger 2 pushes the information button of the closest Passenger Alarm System. The RU Supervisor is presented a livestream of the compartment, first centred on passenger 2.</p>
	Step 2	<p>RU-Supervisor: The RU Supervisor associated to the train answers the call.</p>
	Step 3.x	<p>Passenger 2: reports needing help for passenger 1.</p> <p>For instance, he / she describes the symptoms passenger 1 reported to him/her if/when still conscious.</p>
	Step 4	<p>RUS: The RU Supervisor tunes his/her livestream of the compartment centred to Passenger 1 location, according to Passenger 2's description and body language (hand showing).</p>
	Step 5	<p>RUS: The RU Supervisor qualifies the call as "Person in passenger cabin needing medical assistance".</p> <p>This automatically requires an Infrastructure incident manager, responsible for supporting the incident until its complete solution.</p> <p>Next steps 6, 7, 8, 9, 10, 11 happen in parallel.</p>
	Step 6	Assist person in need during travel
	Step 6.1	<p>RUS: invites Remote Emergency Medical Technician in the call.</p>
	Step 6.2	<p>REMT: assesses situation together with passenger 1 and 2.</p>
	Step 6.3	<p>REMT: ask RUS for support by some medically skilled person.</p>
	Step 6.4.1	<p>RUS broadcasts request for some doctor or nurse in wagon x, also with defibrillator shooting skill. (in parallel with 6.4.2).</p>

	Step 6.4.2	REMT asks and advises Passenger 2 to get the closest semi-automatic external defibrillator kit e.g.,
	Step 6.4.3	Passenger 2: notifies REMT that he/she has the defibrillator kit
	Step 6.4.5	Passenger 3: Passenger 3 is supposed to be somebody with medical skills answering RU's call for help in step 6.4.1. Passenger 3 takes over Passenger 2 if there on time. If not, passenger 2 proceeds in next steps. Passenger 2-3 is the name of this.
	Step 6.4.6	Passenger 2-3: Apply the defibrillator to Passenger 1, as instructed / advised by REMT.
	Step 6.4.7	Passenger 2-3: Apply further life-saving gestures to Passenger 1 until the train reaches rescue area.
	Step 8	Adapt train journey
	Step 8.1	IIM: defines an Emergency Trip. skipping one station, seeking for medical aid in the next.
	Step 8.2	Train: requires from the operations manager an emergency travel to the station after next station.
	Step 8.2	OM: The Operations Manager amends traffic so that the emergency travel's duration can be shortened.
	Step 9	Lead Emergency Medical Technicians to off-boarding platform
	Step 9	IIM: The infrastructure incident manager coordinates medical aid via OMTS for passenger 1. In person medical aid happens best only in 2 stations. Jump to both 8.x, 9.x., 10.x in parallel.
	Step 9.1	Infrastructure incident manager attends the medical aid team on their way to the emergency platform, by opening the gates on their path, and guiding them to the place on the station where, once train has stopped, the closest door to passenger 1 (may be parallel to 10.1).
	Step 9.2	Emergency medical technician reaches the platform. They wait for the train where the closest door to passenger 1 will open
	Step 10	Hand-over from REMT to EMT
	Step 10.1	EMT team is connected to REMT by phone

Step 10.2	REMT briefs EMT team about current situation / past attempts
Step 10.3	REMT propose EMT to listen further to the conversation with passenger 2-3.
Step 11	Off-board passenger 1 (handover RU->IM)
Step 11.1	The train enters the station. It opens its doors. It will not resume mission until the incident is acknowledged as solved.
Step 11.2	The emergency team takes charge / performs first diagnostic / assists passenger 1 until he/she can be loaded on a stretcher.
Step 11.3	Passenger 1 is disposed on a stretcher and off-boarded.
Step 11.4	The medical assistance team notifies the infrastructure incident manager that passenger 2 is off-boarded.
Step 12.5	Medical assistance team: asks the infrastructure incident manager for a calm environment on the platform. Jump to both Step 13 and 1.
Step 13	Adapt traffic to rescue on platform
Step 12.6	Infrastructure incident manager requires some temporary speed restriction for trains driving along the platform and some restriction for alighting at this platform.
Step 12.7.1	operations manager sets some temporary speed restriction for trains driving along the platform and forbids alighting at this platform.
Step 12.7.2	operations manager: He/she reschedules traffic accordingly.
Step 13	Resume train operations
Step 114	RUS: The RU-Supervisor acknowledges the incident solving on the train. The operations manager is automatically notified. (This aspect will be evaluated while authorizing the departure of autonomous train ([SRS X2Rail-4] v0.3, §13.4.6).
Step 12.6	RUS: The RU-supervisor informs the incident no longer delays the train, and doors will close soon.
Step 12.7	RUS: The RU-supervisor closes doors and engages ATO.

	Step 12.8	The train resumes its mission. (see e.g. [SRS x2Rail4], §13.2.1 Elaborate mission and journey profiles)
	Step 15	Provide Passenger 1 with assistance on platform
	Step 15.0	The state of Passenger 1 is further stabilized on the platform.
	Step 15.1	Passenger 1 is rolled out to an emergency vehicle.
	Step 15.2	EMT: As soon as Passenger 1 has left the platform, the medical assistance team notifies the infrastructure incident manager.
	Step 16	Render platform to normal and resume traffic operations
	Step 16.1	IIM: The infrastructure incident manager revokes request for TSRs / alighting restriction in Step 12.7.
	Step 16.2	OM: The operations manager deletes the TSR and lighting restriction on the platform.
	Step 16.3	IIM: The infrastructure incident manager continues to attend the medical assistance team on their way outside the rail facilities. He / she may open gates on their path to exit the station.
	Step 16.4	IIM: After passenger 1 has left the station for an emergency vehicle, the EMT team notifies IIM that they have left the facility.
	Step 16.5	IIM: The infrastructure incident solving manager closes the incident.
Postcondition		<ul style="list-style-type: none"> • Passenger 1 is on his/her way to the hospital. • Operations have resumed normally. • Train continues according to new JP.
Use case notes		<p>UC5.1-047, UC5.1-054, UC5.1-056 and UC5.1-55 are closely related. See also [SRS X2Rail-4] v0.3:</p> <ul style="list-style-type: none"> • §11.11.5 Manage temporary speed restriction • §13.2.1 Elaborate mission and journey profiles • §13.4.6 Authorize departure of autonomous train

Table 1: Use case “Person in passenger cabin needing medical assistance, detected by actor” description

1.56 UC5.1-056: HANDLE RESCUE OPERATION AFFECTING PLATFORM – RESCUE OPERATION ON PLATFORM

Use case field	Description	
ID	UC5.1-056	
Use case name	Handle rescue operation affecting platform - Rescue operation on platform	
Main actor	Person on platform (via Platform Help Intercom),	
Other actors	<ul style="list-style-type: none"> • Incident Manager • Railway Security Officer(s) • Firefighters • Operations Manager • Train(s) 	
Use case summary	<p>Some rescue operation affects a platform, the train traffic along the platform is reduced to Vmax_RescueOnPlatform.</p> <p>To make this example practical, a trash burning on a platform is taken as example. It permits to illustrate:</p> <ul style="list-style-type: none"> • Train traffic along the platform is reduced to Vmax_RescueOnPlatform. <p>In this example, it allows safe work by the emergency team (fire brigade), avoids driving too fast along Person on platforms forced by the fire to edge of the platform</p> <ul style="list-style-type: none"> • No more train is allowed to exchange Person on platform along the platform on which the trash lies <p>As the fire may narrow the width on the platform and, in case of big traffic on the platform, lead the people to fall on track (trying to avoid both heat and crowd pressure toward exit)</p> <p>The fire is considered little enough to apply those limitations only on one platform. Please considered that for other emergencies (terrorism, smoke emitting fires in underground stations), several platforms may be restricted.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: ATO-GoA4, Incident Management System-ATP • Operational category: All 	
Main goal	The goal of this use-case is to demonstrate the implementation of 'skip station', temporary speed limits and alighting ban for a station.	
Preconditions	A fire starts in a trash-can on a platform. Trains running on the line are operating in GoA4.	
Termination outcome	Successful outcomes	Trains drive along the platform with restricted speed Vmax_RescueOnPlatform.

		No more train is allowed to exchange Person on platform along the platform on which the trash lies
	Unsuccessful outcomes	<p>While working, a fireman/woman has to move along the platform's edge. A train driving along the platform at an excessive speed endangers him/her.</p> <p>A Person on platform is pressed by the crowd towards the platform exit. The fire lies in the way. The Person on platform comes closer to the platform edge. A train driving along the platform at an excessive speed endangers him/her.</p> <p>Damage to people or things due to the fire itself.</p>
Condition affecting termination outcome	Outcome 2	N/A
	Step 1.1	Person on platform: A Person on platform on the platform triggers the Platform Help Intercom.
	Step 1.2	Incident manager: An incident manager responsible for the platform or station on which the Platform help intercom is, answers the call.
	Step 1.3	Person on platform: describes a fire on the platform
	Step 2	<p>The incident manager declares an incident.</p> <p>Next steps 3.x to 7.x happen in parallel as part of the incident solving.</p>
	Step 3.	Incident manager: calls the fire brigade.
	Step 4.	Incident manager: locates in his/her IT system the platform section on which the fire lies.
	Step 5.1	<p>Incident Management System: automatically, the operations manager responsible for the station is notified.</p> <p>Next steps 6.x and 7.x happen in parallel.</p>
	Step 5.2	<p>Operations manager: sets a temporary speed restriction TSR = Vmax_RescueOnPlatform along the platform, pre-calculated for the platform.</p> <p>Operations manager: forbids train stop along the burning platform section.</p> <p>From now on, all trains moving toward the platform will be informed of those restrictions</p>
	Step 5.3	<p>Train(s): All trains in approach of the platform, notified according to 6.2:</p> <ul style="list-style-type: none"> • drive along the platform with speed at most TSR.

		<ul style="list-style-type: none"> • skip platform stop.
	Step 6.1	Incident Manager: sends security officer(s).
	Step 6.2	Security Officer(s): open gates for fire brigade, show them the way to the fire.
	Step 6.3	Security Officer(s): manage the flow of Person on platforms entering / leaving the platform.
	Step 6.4	Firefighters: reach fire place e.g., led by some security officer.
	Step 6.5	Firefighters: fight the fire.
	Step 6.6	Fire: extinguishes.
	Step 8	Security officer(s): report that the fire is extinguished. Fire brigade and security officer leave the platform.
	Step 9	Incident manager: revokes the incident. He/she informs the operations manager.
	Step 10	Operations manager: revokes restrictions for the platform set in step 5.1.
	Step 11	Train(s): are no longer restricted while driving along the platform (max speed, stopping restriction revoked).
Postcondition		<ul style="list-style-type: none"> • Normal operations around the platform have resumed. • The fire is extinguished. • The incident is completed.
Use case notes		N/A

Table 1: Use case “Handle rescue operation affecting platform - Rescue operation on platform” description

1.57 UC5.1-057: EVACUATION AND EMERGENCY PROCEDURES: DETRAINMENT PROCEDURES

Use case field	Description	
ID	UC5.1-057	
Use case name	Evacuation and emergency procedures: Detrainment procedures	
Main actor	On-board Automation System (OAS)	
Other actors	<ul style="list-style-type: none"> • Fleet Management System (FMS) • Operations Manager (OM) • Incident Management System (IMS) 	
Use case summary	This use case details the actions to be taken for opening the saloon doors, detrainment doors, or both due to an incident detected (e.g., a passenger triggers an alarm handle, fire on board) while the train is running.	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: • Operational categories: passenger, urban, regional, mainline. 	
Main goal	Manage the opening of train doors according to the significance of the incident.	
Preconditions	<ul style="list-style-type: none"> • Train is performing the actual mission until an incident is detected. • Incidents could arise from TCMS, PER, ADM, or signalling systems. • The next on-board modules should accomplish the following: The ADM module should be in the Engaged State (EG), where the ADM is responsible for driving the train during the mission. On the other hand, the APM module should be Operational in the GoA4 State (GoA4), where the APM replaces the driver for managing the mission execution and for reacting to incidents. Finally, The REP state should be in the Operational State (OP). In this case, the REP should collect and report incidents to the trackside, specifically to the IPM-ISM. • Train doors (saloon and/or detrainment doors) will provide an evacuation route for the passengers. • TCMS shall inhibit doors from opening when train is running. • Train protection knows the precise position of the train. • Digital Map includes information of restrictions about doors opening depending on the area where the train is placed (tunnels, viaducts where passengers can fall, etc.) • REP includes information provided by digital map. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Manage the train doors for opening at a safe stopping point when an incident is detected and keep passengers safe.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • An incident is detected; however, the train doors remain closed (possible door failure or loss of communication), and passengers will open the doors in a manually way.

Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	<p>OAS (APM) identifies the type of incident that occurs during the train mission, such as train anomalies, track anomalies, driving anomalies, or surrounding anomalies, which arise from modules, such as the TCMS, signalling system, ADM, and PER.</p> <p>This information should be sent to the IMS for further analysis and possible actions from external staff when the train is stopped.</p> <ul style="list-style-type: none"> • X2Rail-4 Operational Scenario 13.9.6 <i>Fire on Board while running.</i> • X2Rail-4 Operational Scenario 13.9.16 <i>Use of Passenger Alarm during train run.</i>
	Step 2	<p>OAS (APM) checks the impact of the incident and evaluates which doors (saloon or/and detrainment doors should be opened. To do this, OAS (APM) should be capable of providing commands to the TCMS to open the train doors. Therefore, it is necessary to assess the impact of the incident before opening saloon doors and/or detrainment doors. OAS (Train protection) checks the position of the train and identifies possible restrictions due to the area where the train is stopped.</p> <ul style="list-style-type: none"> • If the severity of the incident is sufficient to open only the saloon doors, proceed to Step 2.1. • If the severity of the incident is sufficient to open only the detrainment doors, proceed to Step 2.2. • If the severity of the incident is sufficient to open the saloon doors and detrainment doors, proceed to Step 2.3.
	Step 2.1	<p>OAS (APM) should be capable of providing commands to the TCMS module for opening saloon doors taking into account possible restrictions stored in REP.</p>
	Step 2.2	<p>OAS (APM) should be capable of providing commands to the TCMS module for opening detrainment doors taking into account possible restrictions stored in REP.</p>
	Step 2.3	<p>OAS (APM) should be capable of providing commands to the TCMS module for opening saloon doors and detrainment doors considering possible restrictions stored in REP.</p>
	Step 3	<p>To manage incidents, IMS should be capable of determining the appropriate reaction.</p> <p>IMS interfaces with the OM to manage trackside incidents, such as track and surrounding anomalies, or manage train incidents, such as driving and train anomalies reported by</p>

		the OAS (APM) and then requests a new Journey Profile to FMS when relevant.
	Step 4	X2Rail-4 Operational Scenario 13.7.12 <i>Stop at next station or rescue point.</i> The train should arrive at a stopping or rescue point before the OAS (TCMS) opens the train doors.
	Step 5	OAS (TCMS) shall control the Door Management System. In addition, TCMS shall combine inputs from Train Protection, ADM, APM (replacing the driver in GoA3/4), and speed information to manage access and loading in the train. <i>Regarding detrainment doors, this type of door has a pneumatic mechanism (could be managed via TCMS) for opening and closing, but for the mechanism to fold and store the ramp, the help of train personnel is needed.</i>
Postcondition	Train successfully opens doors according to the commands generated from the APM module.	
Use case notes	<p>Related use cases:</p> <p>X2Rail-4 Deliverable D5.1 WP5 GoA3/4 Specification (SRS 0.3.0):</p> <ul style="list-style-type: none"> • 13.7.12 Stop at next station or rescue point. • 13.9.6 Fire on Board while running. • 13.9.16 Use of Passenger Alarm during train run. 	

Table 1: Use case “Evacuate Train” description

1.58 UC5.1-058: HANDLE EMERGENCY TRIGGERED BY PASSENGER DOORS NOT DETECTED AS CLOSED AND LOCKED (AT PASSENGER EXCHANGE POSITION)

Use case field	Description	
ID	UC5.1-058	
Use case name	Handle emergency triggered by passenger doors not detected as closed and locked (at passenger exchange position)	
Main actor	On-board Automation System (OAS)	
Other actors	<ul style="list-style-type: none"> • Railway Undertaking Supervisor (RUS) • Trackside Automation System (TAS) • Passenger (PAS) • Railway undertaking Mobile Staff (RMS) 	
Use case summary	A doors authorization for passenger exchange has been revoked at passenger exchange position to get ready for departure. However, not all passenger doors can be closed and locked, so that a departure is not possible.	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA4 • Operational category: passenger, urban, regional 	
Main goal	The train becomes ready for departure after passenger exchange.	
Preconditions	<ul style="list-style-type: none"> • Train at passenger exchange position and doors not authorized. • Dwell time for passenger exchange exceeded. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Train is ready for departure.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2: None
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	OAS: Inform passengers that train shall be ready to depart and that passengers shall clear passenger doors.
	Step 2	OAS: Report to TAS an estimated delay of departure.
	Step 3	PAS: Clears passenger door.
	Step 4	OAS: Close and lock passenger door (if doors clear).
	Step 4.1	OAS: Inform RUS about passenger doors not closed and locked (if doors closed and locked status cannot be achieved after timeout).

Step 4.2	RUS: Check situation by means of CCTV.
Step 4.3	RUS: Command forced door closure, (if doors do not close, though they are not blocked by passengers.)
Step 4.3.1	RUS: Command recycle passenger door and check correct door operation, (if doors are closed but not indicated locked).
Step 4.3.2	OAS: Open respective passenger door.
Step 4.4	OAS: Close and lock respective passenger door (if correct door operation is regained).
Step 4.4.1	RUS: Command passenger door disable door remotely via FAS, (if doors closed and locked status still cannot be achieved).
Step 4.4.1.1	RUS: Send RMS to train (if passenger door override cannot be commanded remotely or is not successful).
Step 4.4.1.2	RMS: Check passenger door and disable door locally.
Step 5	OAS: Determine train ready for departure.
Postcondition	Train is ready for departure.
Use case notes	N/A

Table 1: Use case “Handle emergency triggered by passenger doors not detected as closed and locked (at passenger exchange position)” description

1.59 UC5.1-059: HANDLE EMERGENCY TRIGGERED BY PASSENGER DOORS NOT DETECTED AS CLOSED AND LOCKED (NOT AT PASSENGER EXCHANGE POSITION)

Use case field	Description	
ID	UC5.1-059	
Use case name	Handle emergency triggered by passenger doors not detected as closed and locked (not at passenger exchange position)	
Main actor	On-Board Automation System (OAS)	
Other actors	Railway Undertaking Supervisor (RUS)	
Use case summary	Train is at interstation, while a passenger door is detected as not closed and locked.	
Applicability	<ul style="list-style-type: none"> Geographical: European level System level: GoA4 Operational category: passenger, urban, regional 	
Main goal	The train continues the trip to the next station.	
Preconditions	Train moves at interstation. Passenger doors not detected as closed and locked.	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> Outcome 1: Train continues trip to next station with issue resolved.
	Unsuccessful outcomes	N/A
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	OAS: Set traction inhibition.
	Step 2	OAS: Inform RUS about incident doors not closed and locked.
	Step 4	OAS Inform TAS about incident and potential delay.
	Step 3	RUS: Check by means of CCTV that passenger door is still closed.
	Step 4	OAS: Continue to move, (if possible to reach the next station without traction).
	Step 4.1	OAS: Stop train outside non-stopping zone, (if train cannot reach next station).
	Step 4.2	OAS: Inform passengers about intermediate stop and not to open doors and not to leave the train.

Step 4.3	OAS: Inform TAS about incident and intermediate stop.
Step 4.4	RUS: Send RMS to train.
Step 4.5	RMS: Check passenger door and disable door locally, (if possible, to solve the issue by this action).
Step 4.5.1	RMS: Inform RUS and IOM about the need for evacuation, (if train is not able to proceed).
Step 4.5.1.1	RMS, RUS, IOM: initiate evacuation procedure.
Step 5	OAS: Continue to next station stop.
Postcondition	Train continues the trip to the next station.
Use case notes	Continue to move with open door, but maybe with a limited speed today is forbidden by standards. Maybe in a GoA 4 train will need this opportunity.

Table 1: Use case “Handle emergency triggered by passenger doors not detected as closed and locked (not at passenger exchange position)” description

1.60 UC5.1-060: RESOLVING DETECTED OPEN DOORS ON MOVING PASSENGER TRAIN (GoA3)

Use case field	Description	
ID	UC5.1-060	
Use case name	Resolving detected open doors on moving passenger train (GoA3)	
Main actor	On-board Automation System (OAS)	
Other actors	Fleet Management System (FMS) Trackside Automation System (TAS) Staff (GoA3 train attendant or trackside staff) Fleet manager Railway Undertaking Supervisor	
Use case summary	If a door opens during running a train, OAS (TCMS) immediately triggers traction cut-off. OAS must stop the train as soon as possible to prevent passengers from falling out of the train. The train stops even in areas which are not safe stopping areas like tunnels or bridges. In case if fire is detected, the rules for fire supersede this rule. Naming: The train consists of several vehicles, one of these has an open door.	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA3 • Operational category: passenger, urban, regional, mainline, inspection vehicles with staff on-board 	
Main goal	Prevent passenger injuries due to open doors while running.	
Preconditions	Train is running in GoA3 (staff is on-board) There is no fire on board. If during execution of this use case, fire is detected, go to use case "Fire on board". Reason: Fire is more dangerous than one open door, because many more passengers could be affected by fire.	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Train stopped. No passengers were injured. Train continues journey after open door is closed and locked.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2: Train stopped. Door could not be closed and locked.
Condition affecting termination outcome	Outcome 2	Explanations for unsuccessful outcome: <ul style="list-style-type: none"> • The door could not be closed and locked. • It is not possible to evacuate the passenger from the affected vehicle to another vehicle and continue journey with open door (not closed and locked). Post-conditions for unsuccessful outcomes: <ul style="list-style-type: none"> • Passengers must be evacuated. • When no passengers, train can move to a new location. TAS defines new journey and sends it to OAS. • Some operators (e.g., Fleet Manager, Railway Undertaking Supervisor) reviews CCTV recordings of

		the affected door. If the situation is unclear, the operator sends staff or drone (unmanned aerial vehicle) to the location of door failure. Staff/drone searches for injured passengers along the track, which may have fallen out of the train.
Use case scenario	Step 1	OAS detects an open door.
	Step 2	OAS triggers traction cut-off.
	Step 3	OAS stops the train immediately.
	Step 4a	OAS announces on board “Unscheduled Train stop. Please do not leave the train”.
	Step 4b	OAS keeps the doors closed and locked.
	Step 4c	OAS informs TAS and Fleet Automations system about open door.
	Step 4d	OAS informs Train attendant about open door.
	Step 5	Train attendant closes and locks the door.
	Step 5.1	<i>If train attendant is unable to close the door</i> Train attendant evacuates the passengers to another vehicle and closes the affected vehicle. The train may continue with reduced capacity.
	Step 5.1.1	<i>If the passenger cannot be evacuated from the affected vehicle to another vehicle and the internal doors be closed</i> Train attendant informs Fleet Automation system that the train cannot continue service due to the open door. Go to Outcome 2.
	Step 5.2	Train attendant requests Fleet manager to review CCTV recordings to make sure that it is safe to continue service.
	Step 5.2.1	<i>If it cannot be confirmed that it is safe to continue service</i> Fleet manager informs Train attendant that the train cannot continue service and that it will be evacuated. Go to Outcome 2.
	Step 5.3	Fleet manager informs Train attendant that it is safe to continue service.
	Step 5.4	Train attendant informs OAS that the affected vehicle is empty and closed, and that the train can continue service.
	Step 5.5	OAS informs TAS that the affected vehicle is empty and closed, train is ready to continue service.
	Step 5.6	TAS sends a new journey to OAS to stop at the next safe possible passenger exchange location for train evacuation.
Step 5.7	OAS announces on board that the train will move to a safe location for evacuation and then taken out of service.	
Step 5.8	OAS drives the train to the safe passenger exchange location for evacuation. Use case ends.	
Step 6	Train attendant requests Fleet manager to review CCTV recordings to make sure that it is safe to continue service after the door is closed and locked.	

	Step 7	Fleet manager reviews CCTV recordings to make sure that it is safe to continue service.
	Step 7.1	<i>If it cannot be confirmed that it is safe to continue service</i> Fleet manager informs Railway Undertaking supervisor and Train attendant that the train cannot continue service and that the passengers must be evacuated before moving the train. Go to Outcome 2
	Step 8	Fleet manager informs Train attendant that it is safe to continue service.
	Step 9	Train attendant informs OAS that the train can continue service.
	Step 10	OAS informs TAS that the train is ready to continue service.
	Step 11	TAS sends an updated journey to OAS.
Postcondition	<p>Train continues service with the affected door closed and locked.</p> <p>Track is controlled for possibly injured passengers</p>	
Use case notes	<ul style="list-style-type: none"> Recommend discussion: Is immediate braking for stop for all RU acceptable or even required? Reason for braking is that with open door a passenger may fall out and this is more dangerous than stopping in next safe stopping area after tunnel/bridge. 	

Table 1: Use case “Resolving detected open doors on moving passenger train (GoA3)” description.

1.61 UC5.1-061: RESOLVING DETECTED OPEN DOORS ON MOVING PASSENGER TRAIN (GoA4)

Use case field	Description	
ID	UC5.1-061	
Use case name	Resolving detected open doors on moving passenger train (GoA4)	
Main actor	On-board Automation System (OAS)	
Other actors	<ul style="list-style-type: none"> • Fleet Management System (FMS) • Trackside Automation System (TAS) • Staff (GoA3 train attendant or trackside staff) • Fleet manager • Railway Undertaking Supervisor 	
Use case summary	<p>If a door opens during running a train, OAS(TCMS) immediately triggers traction cut-off. OAS must stop the train as soon as possible to prevent passengers from falling out of the train. The train stops even in areas which are not safe stopping areas like tunnels or bridges. In case if fire is detected, the rules for fire supersede this rule.</p> <p>Naming: The train consists of several vehicles, one of these has an open door.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA4 • Operational category: passenger, urban, regional, mainline, inspection vehicles with staff on-board 	
Main goal	Prevent passenger injuries due to open doors while running.	
Preconditions	<ul style="list-style-type: none"> • Train is running in GoA4. • There is no fire on board. If during execution of this use case, fire is detected, go to use case "Fire on board". Reason: Fire is more dangerous than one open door, because many more passengers could be affected by fire. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Train stopped. No passengers were injured. Train continues journey after open door is closed and locked.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2: Train stopped. Door could not be closed and locked.
Condition affecting termination outcome	Outcome 2	<p>Explanations for unsuccessful outcome:</p> <ul style="list-style-type: none"> • The door could not be closed and locked. • It is not possible to evacuate the passengers from the affected vehicle to another vehicle and continue journey with open door (not closed and locked). <p>Post-conditions for unsuccessful outcomes</p> <ul style="list-style-type: none"> • Passengers must be evacuated. • When no passengers, train can move to a new location. TAS defines new journey and sends it to OAS. • Some operators (e.g., Fleet Manager, Railway Undertaking Supervisor) reviews CCTV recordings of

		the affected door. If the situation is unclear, the operator sends staff or drone (unmanned aerial vehicle) to the location of door failure. Staff/drone searches for injured passengers along the track, which may have fallen out of the train.
Use case scenario	Step 1	OAS detects an open door.
	Step 2	OAS triggers traction cut-off.
	Step 3	OAS stops the train immediately.
	Step 4a	OAS announces “Unscheduled Train stop. Please do not leave the train”.
	Step 4b	OAS keeps the doors closed and locked.
	Step 4c	OAS informs TAS and Fleet Automations system about open door.
	Step 5	OAS closes and locks the open door.
	Step 5.1	<i>If the door cannot be closed and locked</i> OAS requests passengers to evacuate the affected vehicle and move to another vehicle.
	Step 5.1.1	<i>If the passengers cannot move to another vehicle</i> Passenger cannot evacuate the affected vehicle and move to another vehicle. Go to Outcome 2
	Step 5.2	Fleet manager reviews CCTV recordings to make sure the affected vehicle is empty and that it is safe to continue service.
	Step 5.2.1	<i>If it cannot be confirmed that the affected vehicle is empty or that it is safe to continue service</i> Fleet manager informs OAS that the train cannot continue service and that it will be evacuated. Go to Outcome 2.
	Step 5.3	Fleet manager informs OAS that the affected vehicle is empty.
	Step 5.4	OAS closes the internal doors of the affected vehicle and isolates the affected vehicle from the rest of the train.
	Step 5.4.1	<i>If the internal doors cannot be closed</i> OAS informs Fleet Manager that the affected vehicle cannot be isolated. Go to Outcome 2
	Step 5.5	OAS informs TAS that the affected vehicle is empty and isolated.
	Step 5.6	TAS sends a new journey to OAS to stop at the next safe possible passenger exchange location for train evacuation.
	Step 5.7	OAS announces on board that the train will move to a safe location for evacuation and then taken out of service.
Step 5.8	OAS drives the train to the safe passenger exchange location for evacuation. Use case ends.	
Step 6	OAS informs TAS and Fleet Automations system that the door is closed and locked.	
Step 7	Fleet manager reviews CCTV recordings to make sure that it is safe to continue service.	

	Step 7.1	<i>If it cannot be confirmed that it is safe to continue service</i> Fleet manager informs Railway Undertaking supervisor that the train cannot continue service and that passenger must be evacuated before moving the train. Go to Outcome 2
	Step 8	Fleet manager informs OAS that it is safe to continue service.
	Step 9	OAS informs TAS that the train is ready to continue service.
	Step 10	TAS sends an updated journey to OAS.
Postcondition	<p>Train continues service with the affected door closed and locked.</p> <p>Track is controlled for possibly injured passengers.</p>	
Use case notes	<ul style="list-style-type: none"> Recommend discussion: Is immediate braking for stop for all RU acceptable or even required? Reason for braking is that with open door a passenger may fall out and this is more dangerous than stopping in next safe stopping area after tunnel/bridge. 	

Table 1: Use case “Resolving detected open doors on moving passenger train (GoA4)” description

1.62 UC5.1-062: REACT TO CARGO IRREGULARITIES

Use case field	Description	
ID	UC5.1-062	
Use case name	React to cargo irregularities	
Main actor	Trackside Automation System (TAS)	
Other actors	<ul style="list-style-type: none"> On-board Automation System (OAS) Staff (Driver GoA2, Train attendant GoA3, or trackside staff) Railway Undertaking Supervisor (RUS) 	
Use case summary	<p>If a cargo irregularity is detected by the trackside detection system, the OAS is informed by the TAS/Railway Undertaking Supervisor about the necessary reaction (immediate stop or stop at the next station). OAS must implement the necessary reaction. Depending on the detected irregularity, the reaction might be safety relevant.</p> <p>After stopping the train, a check of the actual train conditions is carried out, by the staff (train driver in GoA2, train attendant GoA3; trackside staff can support if necessary). During the check, constant communication with the technical expertise (intervention centre) shall be ensured.</p> <p>After assessing the actual train conditions, a decision is taken whether the train is fit to continue running.</p>	
Applicability	<ul style="list-style-type: none"> Geographical: European level System level: GoA2, GoA3, GoA4 Operational category: freight <p>Note: It is assumed that GoA3 is not applicable for cargo trains. GoA3 relies on the presence of a train attendant on passenger trains; cargo trains are not expected to be staffed with train attendants.</p>	
Main goal	Prevent accidents and incidents due to cargo irregularities (for safety and availability reasons)	
Preconditions	Cargo train is running with a not yet detected irregularity.	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> Outcome 1: Train stopped and checked. Based on the train conditions, the train continues running or is taken out of service for maintenance.
	Unsuccessful outcomes	<ul style="list-style-type: none"> Outcome 2: Train not stopped. Outcome 3: The train is stopped, but the reported cargo irregularity and the actual train conditions are not inspected. Outcome 4: The train is stopped and checked, it is deemed fit for running after the inspection of the train actual conditions but the train could not continue running.
Condition affecting termination outcome	Outcome 2	<p>Explanations for unsuccessful outcomes:</p> <ul style="list-style-type: none"> The train is not stopped. <p>Post-conditions for unsuccessful outcomes:</p>

		<ul style="list-style-type: none"> A freight train is running with an unchecked detected cargo irregularity, potentially leading to incidents or accidents (potential impact on safety and/or availability, depending on the cargo irregularity).
	Outcome 3	<p>Explanations for unsuccessful outcomes:</p> <ul style="list-style-type: none"> The train is stopped, but the reported cargo irregularity and the actual overall train conditions are not inspected. <p>Post-conditions for unsuccessful outcomes:</p> <ul style="list-style-type: none"> A freight train is stopped and not authorized to restart running (availability issue).
	Outcome 4	<p>Explanations for unsuccessful outcomes:</p> <ul style="list-style-type: none"> The train is stopped and checked, it is deemed fit for running after the inspection of the train actual conditions but the train could not continue running. <p>Post-conditions for unsuccessful outcomes:</p> <ul style="list-style-type: none"> A freight train is stopped and is not capable of restarting running (availability issue).
Use case scenario	Step 1	TAS detects a cargo irregularity.
	Step 2	TAS decides if the train should be stopped: <ul style="list-style-type: none"> Immediately At the next station
	Step 3	TAS informs RUS about the detected cargo irregularity and the required stop.
	Step 4	TAS generates new journey and informs OAS that the train must be stopped according to the decision from Step 2 (immediately or at the next station).
	Step 5	OAS stops the train immediately or at the next station by applying the service brake and informs the staff (GoA2 and GoA3) about the reason for the stop: cargo irregularity detected by TAS.
	Step 5.1	<i>If the train cannot be stopped.</i> OAS cannot stop the train, go to Outcome 2.
	Step 6	Staff (Driver GoA2, train attendant GoA3, trackside staff GoA4) performs a check of the detected cargo irregularity and the train condition once the train is stopped.
	Step 6.1	<i>If the staff cannot perform the check.</i> Staff cannot perform the check of the train in a satisfactory manner, go to Outcome 3.
	Step 6.2	<i>If the train is deemed not fit to continue service</i> Staff reports to RUS that the train is deemed <u>NOT</u> fit to continue service.
	Step 6.2.1	RUS informs TAS that the train is <u>NOT</u> fit to continue service.
	Step 6.2.2	RUS takes the required action to evacuate the train.
	Step 6.3	<i>If the train is deemed fit to continue service</i> Staff reports to the RUS that the train is deemed fit to continue service.
	Step 6.3.1	RUS informs TAS that the train is fit for running.

	Step 6.3.2	TAS updates train journey and informs OAS that the train can continue service.
	Step 6.3.2.1	OAS fails to continue service, go to Outcome 4.
	Step 6.3.3	OAS continues service with the updated journey.
Postcondition	<p>The cargo irregularity has been checked and the required actions to avoid incident has been taken:</p> <ul style="list-style-type: none"> • Train is evacuated. • Irregularity resolved and train continues service. 	
Use case notes	<p>1) List of cargo irregularities detected by wayside train monitoring system (WTMS) (priority order):</p> <ul style="list-style-type: none"> • Fire alarm - safety • Hot box detected, temperature difference between axles - safety • Gauge violation (load misplaced / moved) – safety • Clearance profile violation - safety • Asymmetric wheel loads - safety • „warm“ box (warning, high temperature but lower than hot box), brake blocked – safety • Axle overload – safety • Rough wheel defect – safety • Train weight - safety • Contact line uplift - availability • Dragging equipment detected - gauge violation (below the train) - availability <p>2) Overview of what happens outside the train direct interfaces, based on the current SBB processes: On the SBB network, the cargo irregularity detection is ensured by the trackside detection system. Two reactions are possible: immediately stop the train (for safety reasons) or run until next station. The reaction is determined by the type of detected cargo irregularity. Typically, detected cargo irregularities with safety impact lead to an immediate train stop. The SBB intervention centre supervises the detection alarms and is crucial in supporting during the inspection of the train conditions. Communication with the intervention centre needs to be ensured.</p> <p>3) This use case might partially overlap other use cases, such as</p> <ul style="list-style-type: none"> • UC5.1-037 “Handle hot wheel due to brake failure - Brake failure detected through hot boxes detector: continue to next station” • UC5.1-038 “Handle hot wheel due to brake failure - Brake failure through hot boxes detector: stop immediately”. <p>A comparison between the use cases is suggested.</p>	

Table 1: Use case “React to cargo irregularities” description

1.63 UC5.1-063: HANDLE DOOR MALFUNCTION IN LOCOMOTIVE / MULTIPLE

1.63.1 UC5.1-063A: Train attendant on board (GoA3)

Use case field	Description	
ID	UC5.1-063A	
Use case name	Handle door malfunction in Locomotive / Multiple – Train attendant on board	
Main actor	On-Board Automation System (OAS) incl. TCMS	
Other actors	<ul style="list-style-type: none"> • Train attendant (TA) • Trackside automation System (TAS) • Railway Undertaking Supervisor (RUS) 	
Use case summary	This use case details the actions to be taken in case a door failure is detected during door closing.	
Applicability	<ul style="list-style-type: none"> • Geographical: European • System level: System (GoA3) • Operational category: passenger, urban, regional, mainline 	
Main goal	The main objective is to ensure that the affected door is sufficiently sealed, the train unit can continue its mission and the safety of passengers and personnel is ensured.	
Preconditions	<ul style="list-style-type: none"> • Train Unit is in service at platform. • Passenger exchange was performed. • TCMS controls doors and closes doors. • Train attendant on board. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Door closed and sealed; Train continues mission. • Outcome 6: Door closes (obstruction removed); Train continues mission.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2*: Door closed and sealed; Evacuation of vehicle; Train continues mission with limited capacity. • Outcome 3: Door cannot be closed and sealed (in time) -> Update of mission (current mission cancelled). • Outcome 5: Door closed and sealed; Number of doors in use insufficient -> Evacuation of passengers and update of mission (current mission cancelled).
Condition affecting termination outcome	Outcome 2	<ul style="list-style-type: none"> • Train Unit is in passenger service. • Number of doors in service for the train compartment / carriage is insufficient.
	Outcome 3	<ul style="list-style-type: none"> • Current journey without passengers (e.g., platform to stabling area).
	Outcome 4	<ul style="list-style-type: none"> • Train Unit is in passenger service.

	Outcome 5	<ul style="list-style-type: none"> Number of doors in service for the whole train unit is insufficient.
Use case scenario	Step 1	OAS reports door failure (after automatic re-tries).
	Step 2	OAS assesses situation.
	Step 3	OAS triggers TCMS to retry door closure (open doors followed by close doors either for all doors or selected door control).
	Step 3.1	Door closes automatically (either by itself or due to external handling).
	Step 3.2	OAS closes incident case.
	Step 3.3	→ Outcome 6: Door closes (obstruction removed); Train continues mission.
	Step 4	OAS triggers TCMS to retry door closure (open doors followed by close doors either for all doors or selected door control) and reports incident to train attendant (if available).
	Step 4.1	Door closes automatically (either by itself or due to external handling).
	Step 4.2	OAS closes incident case and reports to train attendant that case is closed.
	Step 4.3	→ Outcome 6: Door closes (obstruction removed); Train continues mission.
	Step 5	Train attendant arrives at the door and assesses situation.
	Step 5.1	Train attendant (removes obstruction and) door closes automatically or manually.
	Step 5.2	→ Outcome 6: Door closes (obstruction removed); Train continues mission.
	Step 6	Train attendant closes door manually and seals door.
	Step 6.1	Train attendant cannot close the door manually (jammed door) and reports to RUS and OAS.
	Step 6.2	OAS updates train capabilities, sends report to TAS.
	Step 6.3	<ul style="list-style-type: none"> Outcome 3: Door cannot be closed and sealed (in time) -> Update of mission.
	Step 7	TCMS receives signal that door is closed and sealed.
	Step 8	OAS receives report that door is closed and sealed.
Step 9	OAS assesses situation, updates train capabilities, sends report to TAS and closes incident.	

	Step 9.1	OAS assesses situation and concludes that mandatory amount of doors for service is not sufficient.
	Step 9.2	OAS triggers evacuation of train compartment / carriage and reports to train attendant.
	Step 9.3	Train attendant evacuates passengers from train compartment / carriage.
	Step 9.4	OAS updates train capabilities, sends report to TAS and closes incident.
	Step 9.5	TAS reports to RUS.
	Step 9.6	➔ Outcome 2*: Door closed and sealed; Evacuation of vehicle; Train continues mission with limited capacity.
	Step 10	TAS reports to RUS.
	Step 11	➔ Outcome 1: Door closed and sealed; Train continues mission.
Postcondition	<ul style="list-style-type: none"> • Train unit continues service. • Door is closed and sealed (out of service). • Train Unit capabilities have been updated. • OCC of RU is informed. • Door status is indicated to passengers and personnel (e.g., status light or sticker). 	
Use case notes	<p><i>*Outcome 2 and 4: The rules for the evacuation of certain train carriages or part of the passenger compartments as well as the overall train unit are subject to the national rules and rules of the respective railway undertaking. Multiple unusable doors or a specific combination might require evacuation due to doors not being usable in case of an emergency.</i></p> <p>X2Rail-4: 13.9.20, 13.9.21, 13.9.22</p>	

Table 1: Use case “Handle door malfunction in Locomotive / Multiple – Alternative A” description

1.63.2 UC5.1-063B: Handle door malfunction in Locomotive / Multiple – Train unit not staffed (GoA4)

Use case field	Description	
ID	UC5.1-063B	
Use case name	Handle door malfunction in Locomotive / Multiple – Train unit not staffed (GoA4)	
Main actor	On-Board Automation System (OAS)	
Other actors	<ul style="list-style-type: none"> • TCMS • Railways Mobile (Technical) staff** (RMS) • Trackside automation System (TAS) • Railway Undertaking Supervisor (RUS) 	
Use case summary	This use case details the actions to be taken in case a door failure is detected during door closing.	
Applicability	<ul style="list-style-type: none"> • Geographical: European • System level: System (GoA4) • Operational category: passenger, urban, regional, mainline 	
Main goal	The main objective is to ensure that the affected door is sufficiently sealed, the train unit can continue its mission and the safety of passengers and personnel is ensured.	
Preconditions	<ul style="list-style-type: none"> • Train Unit is in service at platform. • Passenger exchange was performed. • TCMS controls doors and closes doors. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Door closed and sealed; Train continues mission. • Outcome 6: Door closes (obstruction removed); Train continues mission.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2*: Door closed and sealed; Evacuation of vehicle; Train continues mission with limited capacity. • Outcome 3: Door cannot be closed and sealed (in time) -> Update of mission (current mission cancelled). • Outcome 4*: Door cannot be closed and sealed (in time) -> Evacuation of passengers and update of mission (current mission cancelled). • Outcome 5: Door closed and sealed; Number of doors in use insufficient -> Evacuation of passengers and update of mission (current mission cancelled).
Condition affecting termination outcome	Outcome 2	<ul style="list-style-type: none"> • Train Unit is in passenger service. • Number of doors in service for the train compartment / carriage is insufficient.
	Outcome 3	<ul style="list-style-type: none"> • Current journey without passengers (e.g. platform to stabling area).

	Outcome 4	<ul style="list-style-type: none"> • Train Unit is in passenger service.
	Outcome 5	<ul style="list-style-type: none"> • Number of doors in service for the whole train unit is insufficient.
Use case scenario	Step 1	OAS reports door failure (after automatic re-tries).
	Step 2	OAS assesses situation.
	Step 3	OAS triggers TCMS to retry door closure (open doors followed by close doors either for all doors or selected door control).
	Step 3.1	Door closes automatically (either by itself or due to external handling).
	Step 3.2	OAS closes incident case.
	Step 3.3	→ Outcome 6: Door closes (obstruction removed); Train continues mission.
	Step 4	OAS triggers TCMS to retry door closure (open doors followed by close doors either for all doors or selected door control) and reports incident TAS.
	Step 4.1	Door closes automatically (either by itself or due to external handling).
	Step 4.2	OAS closes incident case and reports to TAS that case is solved.
	Step 4.3	→ Outcome 6: Door closes (obstruction removed); Train continues mission.
	Step 5	TAS assesses situation and reports to RUS.
	Step 6	RUS evaluates situation and requests technical staff to solve the problem.
	Step 6.1	RUS concludes that a change of mission as technical staff would not be available on site in a specific time.
	Step 6.1.1	<ul style="list-style-type: none"> • Outcome 3: Door cannot be closed and sealed (in time) -> Update of mission (current mission cancelled).
	Step 6.2	RUS reports to TAS to assist in evacuation of the train unit and updates mission.
Step 6.3	TAS assists in evacuation – announcement and all doors open.	
Step 6.4	RUS announces evacuation to passengers.	
Step 6.5	<ul style="list-style-type: none"> • Outcome 4: Door cannot be closed and sealed (in time) -> Evacuation of passengers and update of mission (current mission cancelled). 	

	Step 7	Technical Staff arrives at the door and assesses situation.
	Step 7.1	Technical staff removes obstruction and door closes automatically or manually.
	Step 7.2	<ul style="list-style-type: none"> • Outcome 6: Door closes (obstruction removed); Train continues mission.
	Step 8	Technical Staff closes door manually and seals door.
	Step 8.1	Technical Staff cannot close the door manually (jammed door) and reports to RUS and OAS.
	Step 8.2	OAS updates train capabilities, sends report to TAS .
	Step 8.3	<ul style="list-style-type: none"> • Outcome 3: Door cannot be closed and sealed (in time) -> Update of mission.
	Step 9	TCMS receives signal that door is closed and sealed.
	Step 10	OAS receives report that door is closed and sealed.
	Step 11	OAS assesses situation, updates train capabilities, sends report to TAS and closes incident.
	Step 11.1	OAS assesses situation and concludes that mandatory amount of doors for service is not sufficient*.
	Step 11.2	OAS triggers evacuation of train compartment / carriage and reports to RUS*.
	Step 11.3	Technical staff evacuates passengers from train compartment / carriage.
	Step 11.4	OAS updates train capabilities, sends report to TAS and closes incident.
	Step 11.5	TAS reports to RUS.
	Step 11.6	<ul style="list-style-type: none"> • Outcome 2*: Door closed and sealed; Evacuation of vehicle; Train continues mission with limited capacity.
	Step 12	TAS reports to RUS.
	Step 13	<ul style="list-style-type: none"> • Outcome 1: Door closed and sealed; Train continues mission.
Postcondition		<ul style="list-style-type: none"> • Train Unit continues service. • Door is closed and sealed (out of service). • Train Unit capabilities have been updated. • OCC of RU is informed. • Door status is indicated to passengers and personnel (e.g., status light or sticker).
Use case notes		<i>*The rules for the evacuation of certain train carriages or part of the passenger compartments as well as the overall train unit are subject to the national rules and rules of the respective railway undertaking. Multiple</i>

	<p><i>unusable doors or a specific combination might require evacuation due to doors not being usable in case of an emergency.</i></p> <p>**Technical staff refers to a person authorised and skilled to solve the problem. Job position or allocation to an entity are to be defined by the RUS, i.e. the technical staff could also be a person authorised to perform that task on site or personnel staffed on other train unit for instance.</p> <p>X2Rail-4: 13.9.20, 13.9.21, 13.9.22</p>
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Table 2: Use case “Handle door malfunction in Locomotive / Multiple – Alternative B” description

1.64 UC5.1-064: RESOLVING A DETECTED HVAC FAILURE AT A PLATFORM

Use case field	Description	
ID	UC5.1-064	
Use case name	Resolving a detected HVAC failure at a platform	
Main actor	On-board Automation System (OAS)	
Other actors	<ul style="list-style-type: none"> • Fleet Automation System (FAS) • Railway Undertaking Supervisor (RUS) • Train Attendant (TA) • Trackside Automation System (TAS) 	
Use case summary	This use case details the actions to be taken in case of HVAC inside a carriage of a train unit fails while the train unit is at a platform (station).	
Applicability	<ul style="list-style-type: none"> • Geographical: European • System level: System GoA3/4 • Operational category: passenger, urban, regional, mainline 	
Main goal	The objective of this use case is to reduce the operational impact of the HVAC failure or solve it by short-term measures applied and ensure safe conditions for passengers in the affected parts of the train unit.	
Preconditions	<ul style="list-style-type: none"> • Train Unit is in passenger service. • Train Unit is standing at a platform in a station. • OAS (which includes TCMS) is able to detect the status of HVAC. 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: HVAC is operational. • Outcome 2: Train Unit continues mission with limited capacity (compartment/carriage closed for use).
	Unsuccessful outcomes	→ Outcome 3: Train Unit cannot continue its mission
Condition affecting termination outcome	Outcome 3	<ul style="list-style-type: none"> • Number of carriages / compartments for passenger/personnel use does not meet the criteria set.
Use case scenario	Step 1	OAS (TCMS) detects a failure of the HVAC.
	Step 2	OAS registers incident and assesses situation.
	Step 3	OAS commands: <ul style="list-style-type: none"> • To open doors (if not opened) • Holds train at station • Restart HVAC • Informs TAS
	Step 4	FAS assesses situation.

Step 5	FAS reports incident and status to RUS and TA (if available).
Step 6	OAS indicates that HVAC is not working after restart. → then go to step 7
Step 6.1	OAS indicates that HVAC is working.
Step 6.2	OAS reports status to FAS, RUS and TA (if available) and closes incident.
Step 6.3	<ul style="list-style-type: none"> • Outcome 1: HVAC is operational.
Step 7	OAS assesses situation and concludes that train compartment is not allowed to be used by passengers/personnel.
Step 7.1	OAS assesses situation and concludes that the amount of usable carriages for passengers/personnel does not meet the criteria set.
Step 7.2	OAS: <ul style="list-style-type: none"> • cancels mission for train unit. • triggers evacuation of train unit. • reports to FAS, TAS.
Step 7.3	FAS reports status of incident to RUS, TA.
Step 7.4	→ Outcome 3: Train Unit cannot continue its mission.
Step 8	OAS triggers evacuation of train compartment / carriage and reports to FAS.
Step 8.1	OAS triggers evacuation of train compartment / carriage and reports to TA.
Step 8.3	TA evacuates passengers from train compartment / carriage, marks compartment and announces closure to passengers and confirms evacuation to OAS.
Step 8.4	OAS updates train capabilities, sends report to FAS and closes incident.
Step 8.5	FAS reports status to RUS, TA.
Step 8.6	→ Outcome 2: Train Unit continues mission with limited capacity (compartment/carriage closed for use).
Step 9	FAS reports status to RUS.
Step 10	RUS announces evacuation of train compartment / carriage to passengers.

Step 11	OAS updates train capabilities, sends report to FAS and closes incident.
Step 12	FAS reports to RUS.
Step 13	➔ Outcome 2: Train Unit continues mission with limited capacity (compartment/carriage closed for use).
Postcondition	<ul style="list-style-type: none"> • Train Unit can continue its mission. • HVAC is either operational again OR train compartment or carriage is closed for use by passengers/personnel.
Use case notes	X2Rail-4: 13.9.8 HVAC default in station

Table 1: Use case “Resolving a detected HVAC failure at a platform” description

1.65 UC5.1-065: RESTRICTING TRAIN OPERATIONS WHEN DETECTING DERAILMENT OF ANOTHER TRAIN

Use case field	Description	
ID	UC5.1-065	
Use case name	Restricting train operations when detecting derailment of another train	
Main actor	Trackside Automation System (TAS)	
Other actors	<ul style="list-style-type: none"> • On-board Automation System (OAS), • Physical Train Unit 1 (TU1) • Physical Train Unit 2 (TU2) • Infrastructure Manager (IM) • Emergency Manager (EM) • Railway Undertaking Supervisor (RUS) 	
Use case summary	<p>This use case details the actions to be taken when one train unit detects the derailment of another train (while running).</p> <p>Remark: The scenario here describes a situation where one wagon / carriage of another train is derailed and not yet detected by the train unit itself while running. This might rather apply to (longer) freight trains where wagons could derail prior to detection by the train unit itself.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European Level • System level: System (GoA3/4) • Operational category: mainline, freight, passenger 	
Main goal	The main objective is to report the train unit affected by a derailment and secure safe operations of the train unit reporting.	
Preconditions	<ul style="list-style-type: none"> • Derailment of (part of) the other train unit was not previously detected. • Derailment of wagons / carriages of derailed train unit is detectable (move abnormally/out of the train units loading gauge). 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Derailed train unit is stopped.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Derailed train is not stopped at this point after detection. • Waggons of the derailed train infringe the loading gauge of reporting train ->use case to response to obstacle or collision.
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	OAS (TU1): Detects derailment of carriages of TU2.
	Step 2	OAS (TU1) assesses situation.
	Step 3	OAS (TU1) registers incident.
	Step 4	OAS (TU1)

	<ul style="list-style-type: none"> • commands emergency brake. • commands warning signal. • reports to TAS. <p>all commands can be executed simultaneous.</p>
Step 5	<p>TAS assesses situation and identifies:</p> <ul style="list-style-type: none"> • immediately affected train unit (derailed). • secondary affected train units. • affected track sections.
Step 6	<p>(In case of TU2 is operated in GoA4) TAS commands:</p> <ul style="list-style-type: none"> • usage restrictions on affected track sections*. • reports incident to OAS (TU2). • reports incident to IM, EM, RUS (of affected train units).
Step 6.1	<p>(In case of TU2 is not operated in GoA4) TAS commands:</p> <ul style="list-style-type: none"> • usage restrictions on affected track sections*†. • reports incident to OAS (TU2) <i>if available</i>. • reports to driver of TU2 or other personnel on-board. • reports incident to IM, EM, RUS (of affected train units).
Step 7	<p>OAS (TU2) reacts to the usage restrictions implemented.</p> <p>OAS (TU1) reacts to the usage restrictions implemented.</p> <p>OAS (other TU) reacts to the usage restrictions implemented.</p>
Step 8	<p>TU1 stops before or adjacent to derailed train and assesses situation (health state of train unit).</p>
Step 8.1	<p>TU1 passes derailed train while emergency brake is activated or stops after passing the derailed train.</p>
Step 8.2	<p>TU1 continues mission.</p>
Step 9	<p>TU2 stops:</p> <ul style="list-style-type: none"> • Outcome 1: Derailed train unit is stopped
Postcondition	<ul style="list-style-type: none"> • Derailed train unit (TU2) is stopped. • Train Unit (TU1) detecting the derailment is either stopped or continues mission if the derailed train was passed. • Usage restrictions on affected track sections (primary affected track and secondary affected adjacent tracks).
Use case notes	<p>*The exact track usage restrictions depend on the topology and topography of the affected tracks as well as restrictions being placed for the individual affected trains as the derailed train might need to avoid an abrupt emergency brake but instead rather utilise the service brake to avoid a further escalation of the situation (carriages tipping over).</p>

	<p>It is assumed that the wagons / carriages of the derailed train unit (TU2) do not infringe the mandatory route (loading gauge and buffer) of the detecting train unit (TU1). In this case another use case for the detecting train unit (TU2) applies (<input type="checkbox"/> Respond to object on or near the line).</p>
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Table 1: Use case “Restricting train operations when detecting derailment of another train” description.

1.66 UC5.1-066: HANDLE OVERCROWDED PLATFORM IN STATION DETECTED BY ACTOR

Use case field	Description	
ID	UC5.1-066	
Use case name	Handle overcrowded platform in station detected by actor	
Main actor	TAS	
Other actors	Operations Manager, Police officer(s), OAS, Railway Undertaking Supervisor	
Use case summary	<p>TAS or Operations Manager detects an overcrowding on a platform. People should leave the platform and trains should not depart or pass the platform at a lower speed.</p> <p>The overcrowding can happen at pax-ex or without a train at the platform.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA2, GoA3/4 • Operational category: passenger, urban, regional, mainline, freight, inspection vehicles 	
Main goal	Prevent accidents on platform due to overcrowding	
Preconditions	N/A	
Termination outcome	Successful outcomes	Outcome 1: Overcrowding is reduced, and the rail traffic can continue, optionally with lower speed
	Unsuccessful outcomes	Outcome 2: Not enough passengers leave the overcrowded area. Rail traffic is stopped.
Condition affecting termination outcome	Outcome 2	<p>The overcrowding is so severe that no safe rail traffic is possible anymore.</p> <p>Postconditions: police ensure a reduction of people on the platform.</p>
Use case scenario	Step 1.1	TAS detects overcrowding on a platform.
	Step 1.2	Operations Manager detects overcrowding on a platform. Operations Manager informs TAS about overcrowding.
	Step 2	TAS announces (text and audio) that the platform is overcrowded, and the passengers should leave the platform. Railway Undertaking Supervisor after instruction by Operations Manager tries to convince the passengers to leave the platform.
	Step 3	TAS sends a temporary speed restriction to all trains departing or passing the platform.

	Step 4	TAS calculates new timetables and sends them to all trains concerned.
	Step 5	TAS or Operations Manager decide that the traffic has to be stopped. Go To Outcome 2.
	Step 6	OAS on passing trains next to the overcrowded platform shall horn (see use case UC5.2-0031)
	Step 7	Not enough passengers leave the overcrowded platform, TAS or Operations Manager calls the police officer (s).
	Step 8	Police officer(s) ensure(s) that the platform will be evacuated.
	Step 9	Overcrowding ended.
	Step 10	TAS revokes speed restrictions.
Postcondition	Timetable is updated and vehicle planning is updated.	
Use case notes	This use case is required only for GoA3/4. In GoA2 it is the task of the driver to handle an overcrowded platform. Therefore, this use case is out of scope for GoA2.	

Table 1: Use case “Handle overcrowded platform in station detected by actor” description

1.67 UC5.1-067: EMERGENCY TRIGGERED BY PLATFORM SCREEN DOORS NOT DETECTED AS CLOSED AND LOCKED (AT PASSENGER EXCHANGE POSITION)

Use case field	Description	
ID	UC5.1-067	
Use case name	Emergency triggered by platform screen doors not detected as closed and locked (at passenger exchange position)	
Main actor	On-board Automation System (OAS)	
Other actors	<ul style="list-style-type: none"> • Operation Manager (OM) • Trackside Automation System (TAS) • Passenger (PAS) • Emergency Manager (IEM) 	
Use case summary	A doors release for passenger exchange has been revoked at passenger exchange position to get ready for departure. However, not all platform screen doors can be closed and locked, so that a departure is not possible.	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA3, GoA4 • Operational category: passenger, urban, regional 	
Main goal	The train becomes ready for departure after passenger exchange.	
Preconditions	Train at passenger exchange position and doors (platform screen door and corresponding train door) are open.	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Train is ready for departure.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2: None
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	TAS: Inform passengers that train shall be ready to depart and that passengers shall clear door area so that driving could be done.
	Step 2	PAS: Clears passenger screen door.
	Step 3	OAS: Close and lock door (if doors clear).
	Step 3.1	TAS: Inform passenger at platform to clear the doors (if closed and lock status cannot be achieved after timeout).
	Step 3.2	TAS: Inform OM about doors not closed and locked.
	Step 3.3	OM: Check situation by means of CCTV.

	Step 3.4	OM: Command forced door closure, to the platform screen door (when the platform screen door is closed, the train door also closes).
	Step 3.4.1	OM: Command platform screen door disable door remotely, (if doors closed and locked status still cannot be achieved).
	Step 3.4.1.1	OM: Send IEM to train (if passenger door override cannot be commanded remotely or is not successful).
	Step 3.4.1.2	IEM: Check doors and close train doors locally and disable platform screen door locally.
	Step 4	OAS: Determine train ready for departure.
	Step 5	TAS: Update travel information for train, (if necessary for overall traffic situation).
Postcondition	Train is ready for departure.	
Use case notes	The passenger doors of the train directly communicate with the opposing platform screen doors for open and closing operation. Therefore, OAS is able to open and close both passenger train doors and platform screen doors.	

Table 1: Use case “Emergency triggered by passenger screen doors not detected as closed and locked (at passenger exchange position)” description

1.68 UC5.1-068: EMERGENCY TRIGGERED BY PASSENGER SCREEN DOORS NOT DETECTED AS CLOSED AND LOCKED (NOT AT PASSENGER EXCHANGE POSITION)

Use case field	Description	
ID	UC5.1-068	
Use case name	Emergency triggered by passenger screen doors not detected as closed and locked (not at passenger exchange position)	
Main actor	Trackside Automation System (TAS)	
Other actors	<ul style="list-style-type: none"> • Railway Undertaking Supervisor (RUS) • Trackside Automation System (TAS) • IM Operations Manager (IOM) • Emergency Manager (IEM) 	
Use case summary	Train is at interstation, while a passenger screen door is detected as not closed and locked.	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA4 • Operational category: passenger, urban, regional 	
Main goal	The train continues the trip to the next station.	
Preconditions	Train moves at interstation. Passenger screen doors not detected as closed and locked.	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Train continues trip to next station.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2: None
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	TAS: Set run authorization zone in platform track.
	Step 2	TAS: Inform RUS and IOM about incident doors not closed and locked.
	Step 3	IOM: Check by means of CCTV that passenger door is still closed.
	Step 4	IOM: Command Platform screen door override (if doors are confirmed to be closed)
	Step 4.1	IOM: Call IMS to disable platform screen door locally (if remote override does not have effect).
	Step 4.1.1	IEM: Disable platform screen door locally.

	Step 5	TAS: Revoke run authorization zone in platform track.
Postcondition	Train continues the trip to the station.	
Use case notes	If a run authorization zone is set, the train shall not be permitted to enter the respective area, i.e., try to stop in front and brake as long as a part of the train is within the area.	

Table 1: Use case “Emergency triggered by passenger doors not detected as closed and locked (not at passenger exchange position)” description

1.69 UC5.1-069: HANDLE BAD CURRENT COLLECTION IN CASE OF WEATHER CONDITIONS (WIND, TEMPERATURES, ETC.)

Use case field	Description	
ID	UC5.1-069	
Use case name	Handle bad current collection in case of weather conditions (wind, temperatures, etc.)	
Main actor	On board Automation System (OAS)	
Other actors	Trackside Automation System (TAS)	
Use case summary	A bad current collection can be due to bad weather, or (not in scope of this use case) a defective catenary or pantograph. In case of a bad current collection due to bad weather, the train can continue driving at a reduced speed.	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA 2/3/4 • Operational category: passenger, urban, regional, mainline, freight 	
Main goal	The train detects a bad current collection and reacts by reducing the speed accordingly.	
Preconditions	The train is running.	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • The train continues driving with a reduced and adapted speed.
	Unsuccessful outcomes	N/A
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	OAS detects bad current collection due to bad weather conditions (no defects reported)
	Step 2	OAS reduces the speed accordingly
	Step 3	OAS reports incident to TAS and inform passengers about the delay.
	Step 4	OAS requests new JP
	Step 5	TAS provides new JP to OAS
	Step 6	The train continues driving at a reduced speed. End of UC
Postcondition	The train continues its journey at a speed which is adapted to the bad current collection.	

<p>Use case notes</p>	<p>The following references have been used:</p> <ul style="list-style-type: none"> - X2Rail-4: 13.8.7 Bad current collection in case of bad current collection <p>In case of a damage in Catenary or Pantograph, refer to:</p> <ul style="list-style-type: none"> - SRS UCs 13.10.6 Damage to catenary - SRS UCs 13.9.1 Damage to pantograph
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Table 1: Use case “Handle bad current collection in case of weather conditions” description

1.70 UC5.1-070: APPLY TEMPORARY SPEED RESTRICTIONS FOR HIGH WINDS

Use case field	Description	
ID	UC5.1-070	
Use case name	Apply temporary Speed Restrictions for High Winds	
Main actor	Operations Manager (OM)*	
Other actors	<ul style="list-style-type: none"> • Trackside Automation System (TAS) • On-board Automation System (OAS) • Incident Management System (IMS) 	
Use case summary	<p>This use case describes the needs and possible solutions for applying temporary speed restrictions owing to high winds and avoiding some incidents. The incidents that can occur are as follows: swaying overhead wires, derailment risk, or instability of sensitive wagons.</p> <p>High winds TSRs are only applicable in areas where high-speed (HS) trains operate. Therefore, on lines equipped with Class B or L1 systems, where the speed limit is up to 200 km/h, they have no relevance or applicability.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European level • System level: GoA3/4 • Operational categories: passenger and mainline. 	
Main goal	OAS applies temporary speed restriction (TSR) on the train due to strong winds.	
Preconditions	<ul style="list-style-type: none"> • Train is performing the actual mission until a high wind event is detected. • Operations Manager has inputs from different sources for weather conditions such as sensors, staff reports, and weather forecasts. • OM must be involved with the communication subsystem to monitor the crosswind detector system to report the status of the system and speed restrictions. 	
Termination outcome	Successful outcomes	<u>Outcome 1:</u> The TSR is applied, and the train slows down. Thus, the passengers remain safe.
	Unsuccessful outcomes	TSR is not executed on the train due to: <u>Outcome 2:</u> Loss of communication with the crosswind detection system. <u>Outcome 3:</u> Disabling the crosswind detection system. There is communication with the system, but an incident has appeared, which does not allow us to predict the wind state.
	Outcome 2	OM does not receive information about the status of the system and speed restrictions due to a communication

Condition affecting termination outcome		failure. This is probably owing to an error in the communication subsystem.
	Outcome 3	The system does not predict the speed and direction wind. This is probably owing to an error in the processing subsystem or acquisition subsystems.
Use case scenario	Step 1	Operation manager receives information of bad weather conditions.
	Step 2	If a critical alarm related to the wind state is generated from the crosswind detection system, OM (human or system) must impose a TSR order.
	Step 2.1	IMS transmits direct orders (about new TSR) to TAS (Train Control).
	Step 2.2	TAS (Train Control) receives the TSR command and transmits the TSR to OAS (Train Protection).
	Step 2.3	OAS (Train Protection) monitors the speed of the train according to the new TSR received and the maximum wind speed able to withstand due to the characteristics of the train.
	Step 3	TAS manages the stopping and passing points according to the TSR impose by OM
	Step 3.1	OAS (REP) obtains the Journey Profile information from TAS.
Postcondition	Train continues the trip with TSR applied.	
Use case notes	<p>*The operations Manager is not an automated systems at this point in time. Future developments could automate this actor.</p> <p>Use cases and information related to this:</p> <p>X2Rail-4 Deliverable D5.1 WP5 GoA3/4 Specification (SRS 0.3.0):</p> <ul style="list-style-type: none"> • 13.8.13 Speed restriction due to weather conditions. • 11.11.5 Manage temporary speed restriction. • 13.2.1 Elaborate mission and journey profiles 	

Table 1: Use case “Apply temporary Speed Restrictions for High Winds” description

General example for wind restrictions for wind warning level for heavy rail.

Note: this is an actual example from DB Nets in Germany and is subject to national rules and line specific rules.

Wind warning level	Measures for		
	Freight trains within affected sections	Freight trains vulnerable to wind accepted by the respective control centre (IM)	Other freight trains in front of affected sections
Level 1 wind speeds 72 - 89 kph	Trains can continue In wind vulnerable sections larger than 2 km, trains are instructed to run with a maximum speed of 80 kph.	Trains should stop at least at main signal in front of affected section Trains can only continue with written order, but only with a maximum speed of 80 kph.	Trains can continue
Level 2 wind speeds 90 - 114 kph	Trains can continue In wind vulnerable sections larger than 2 km, trains are instructed to run with a maximum speed of 60 kph.	Trains should stop at least at main signal in front of affected section. Trains can only continue when no wind warning is lifted.	Trains should stop at least at main signal in front of affected section Trains can only continue with written order, but only with a maximum speed of 80 kph.
Level 3 wind speeds higher than 114 kph	Trains can continue In wind vulnerable sections larger than 2 km, trains are instructed to run with a maximum speed of 40 kph.	Trains should stop at least at main signal in front of affected section. Trains can only continue when no wind warning is lifted.	Trains should stop at least at main signal in front of affected section. Trains can only continue when wind warning level 3 is lifted.

Source: DB Ril 408.1541, 408.3541, 420.0561.

1.71 UC5.1-071: RESTRICTING TRAIN OPERATIONS DUE TO UNAUTHORIZED ESCAPE DOOR OPENING (IN TUNNEL)

Use case field	Description	
ID	UC5.1-071	
Use case name	Restricting train operations due to unauthorized escape door opening (in tunnel)	
Main actor	Trackside Automation System (TAS)	
Other actors	<ul style="list-style-type: none"> • Infrastructure Manager (IM) • Emergency Manager (EM) • Railway Undertaking Supervisor (RUS) • Police 	
Use case summary	This use case details the actions to be taken in case of an unauthorised opening of an escape door (in tunnels).	
Applicability	<ul style="list-style-type: none"> • Geographical: National • System level: Infrastructure System (GoA3/4) • Operational category: passenger, urban, regional, mainline, freight 	
Main goal	The main goal is to stop train operations and allow relevant stakeholders (IM personnel/EM and/or police) to investigate the cause of the unauthorised opening of the escape door and the suspected perpetrator/s.	
Preconditions	<ul style="list-style-type: none"> • Emergency door alarm system is active. • No train units in affected line section (tunnel). 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Track restrictions* in place on affected line sections; Relevant stakeholders are informed and investigating. • Outcome 2: Track restrictions* in place on affected line sections; Third rail is short-circuited, Relevant stakeholders are informed and investigating.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Door was deliberately opened by personnel (not knowing that this would lead to an alarm) -> alarm reset.
Condition affecting termination outcome	Outcome 2	<ul style="list-style-type: none"> • Tracks are equipped with third rail.
Use case scenario	Step 1	Emergency door monitoring in tunnel receives alarm signal that escape door was opened unauthorised.
	Step 2	TAS registers incident.
	Step 3	TAS assesses situation: <ul style="list-style-type: none"> • TAS identifies affected line sections. • TAS identifies affected train units.
	Step 4	TAS

	<ul style="list-style-type: none"> • Commands usage restrictions to affected line sections according to rule set. • Reports to IM, EM (and RUS of affected train units).
Step 4.1 (third rail)	<p>TAS:</p> <ul style="list-style-type: none"> • Commands usage restrictions to affected line sections according to rule set. • Reports to IM, EM (and RUS of affected train units). • Commands a power down of traction current section is affected line sections.
Step 4.2 (third rail)	IM request police support.
Step 4.3 (third rail)	EM arrives on-site and short-circuits the third rail at the affected track sections.
Step 4.4 (third rail)	Police and EM arrive on-site at the door and investigate the unauthorised opening.
Step 4.5 (third rail)	<ul style="list-style-type: none"> • Outcome 2: Track restrictions* in place on affected line sections; Third rail is short-circuited, Relevant stakeholders are informed and investigating.
Step 5	IM request police support.
Step 6	Police and EM arrive on-site at the door and investigate the unauthorised opening
Step 7	<ul style="list-style-type: none"> • Outcome 1: Track restrictions* in place on affected line sections; Relevant stakeholders are informed and investigating.
Postcondition	<ul style="list-style-type: none"> • Train operations are restricted for affected train sections. • Police and Emergency Manager are investigating.
Use case notes	<p>The exact procedure in case of an unauthorised opening of an escape door is subject to the rules of the respective infrastructure operator. This use case might thus not apply to every organisation.</p> <p>*Track restrictions depend on the national operation rules and the rules of the respective infrastructure manager. The restrictions here would in most cases involve speed restrictions within a range from V=0kph (full track closure) or a lower speed (e.g., 40kph) for one or multiple tracks inside the tunnel (depending on the tunnel).</p> <p>Sources:</p> <ul style="list-style-type: none"> • DB: 484.0012 Fluchttürüberwachung (FLÜ)

Table 1: Use case “Restricting train operations due to unauthorized escape door opening (in tunnel)” description

1.72 UC5.1-072: RESTRICTING TRAIN OPERATIONS DUE TO DETECTED TRESPASSING

Use case field	Description	
ID	UC5.1-072	
Use case name	Restricting train operations due to detected trespassing	
Main actor	Trackside Automation System (TAS)	
Other actors	<ul style="list-style-type: none"> • Infrastructure Manager (IM) • Emergency Manager (EM) • Railway Undertaking Supervisor (RUS) • Police 	
Use case summary	<p>This use case details the actions to be taken in case of an alarm from a trespassing detection system. Trespassing detection system can be installed in various parts of the infrastructure depending on the security specification of the respective infrastructure.</p> <p>This use case therefore refers only to trespassing systems of relevant infrastructure elements leading to the restriction of train movements.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: National • System level: Infrastructure System (GoA3/4) • Operational category: passenger, urban, regional, mainline, freight 	
Main goal	The main goal is to stop train operations and allow relevant stakeholders to investigate the cause of the unauthorised opening of the escape door and the suspected perpetrator(s).	
Preconditions	<ul style="list-style-type: none"> • Emergency door alarm system • No train units in affected line section (tunnel) 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Track restrictions in place on affected line sections; Relevant stakeholders are informed and investigating. • Outcome 2: Track restrictions in place on affected line sections; Third rail is short-circuited, Relevant stakeholders are informed and investigating.
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Alarm was deliberately triggered by personnel (not knowing that this would lead to an alarm) -> alarm reset.
Condition affecting termination outcome	Outcome 2	<ul style="list-style-type: none"> • Tracks are equipped with third rail.
Use case scenario	Step 1	Emergency door monitoring in tunnel receives alarm signal that escape door was opened unauthorised.
	Step 2	TAS registers incident.
	Step 3	TAS assesses situation: <ul style="list-style-type: none"> • TAS identifies affected line sections.

	<ul style="list-style-type: none"> TAS identifies affected train units.
Step 4	<p>TAS:</p> <ul style="list-style-type: none"> Commands usage restrictions to affected line sections according to rule set**. Reports to IM, EM (and RUS of affected train units).
Step 4.1 (third-rail only)	<p>TAS:</p> <ul style="list-style-type: none"> Commands usage restrictions to affected line sections according to rule set. Reports to IM, EM (and RUS of affected train units). Commands a power down of traction current section is affected line sections.
Step 4.2 (third-rail only)	IM request police support (and railway security if available*).
Step 4.3 (third-rail only)	EM arrives on-site and short-circuits the third rail at the affected track sections.
Step 4.4 (third-rail only)	Police and EM arrive on-site at the door and investigate the unauthorised opening.
Step 4.5 (third-rail only)	➔ Outcome 2: Track restrictions in place on affected line sections; Third rail is short-circuited, Relevant stakeholders are informed and investigating.
Step 5	IM request police support (and railway security if available*).
Step 6	Police and EM arrive on-site at the door and investigate the unauthorised opening.
Step 7	➔ Outcome 1: Track restrictions in place on affected line sections; Relevant stakeholders are informed and investigating.
Postcondition	<ul style="list-style-type: none"> Train operations are restricted for affected train sections. Police and Emergency Manager are investigating.
Use case notes	<p>The exact procedure in case of an unauthorised opening of an escape door is subject to the rules of the respective infrastructure operator. This use case might thus not apply to every organisation.</p> <p>*This depends on the respective rules and procedures of the infrastructure manager.</p> <p>**the exact parameters for restrictions are subject to the rules of the respective infrastructure manager and might also depend on the localities (tunnel). Usage restrictions are most likely speed restrictions (full track closure, on-sight or other speeds) on either the whole tunnel, tunnel sections or just part of the tracks.</p> <p>Sources:</p> <ul style="list-style-type: none"> 484.0010 Einbruchmeldeanlage (EMA)

	<ul style="list-style-type: none">• 890.2000 Einbruchmeldeanlagen für technische Objekte - Allgemeine Rahmenbedingungen
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Table 1: Use case “Restricting train operations due to detected trespassing” description

1.73 UC5.1-073: SET LOW ADHESION CONDITIONS

Use case field	Description	
ID	UC5.1-073	
Use case name	Set low adhesion conditions	
Main actor	On-board Automation System (OAS)	
Other actors	Trackside Automation System (TAS) Infrastructure Manager (IM)	
Use case summary	Low adhesion conditions are given because of dirty weather, foliage on track or other reasons. In this case, expedition, brake retardation and maybe train speed needs to be limited.	
Applicability	<ul style="list-style-type: none"> Geographical: European level System level: GoA4, GoA3 Operational category: passenger, urban, regional, freight 	
Main goal	The train adopts the driving style adapted to the adhesion conditions.	
Preconditions	Train is operated on mainline.	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> Outcome 1: Train adopts driving style to adhesion level.
	Unsuccessful outcomes	<ul style="list-style-type: none"> Outcome 2: None
Condition affecting termination outcome	Outcome 2	N/A
Use case scenario	Step 1	TAS: Determine change of adhesion level for dedicated track sections, based on information for example from weather forecast, rain radar, temperature, dew point and leaf fall, or information from previous trains.
	Step 1.1	IM: Determine adhesion level for a particular track section, based on trains reporting.
	Step 2	TAS: Set track condition to appropriate adhesion level.
	Step 3	OAS: Receive track conditions from trackside.
	Step 4	OAS: Adopt speed profile including braking profiles to adhesion level.
	Step 5	OAS: Calculate estimated delayed arrival time.
	Step 6	OAS: Inform passengers about estimated delay.
	Step 7	OAS: Report estimated deviating arrival time to TAS.

	Step 8	TAS: Inform passengers at next platform about estimated delay.
	Step 9	TAS: Updating the JP.
Postcondition	Train has adopted its driving style and avoided excessive slip and slide.	
Use case notes	The scenario is suited for downgrading adhesion levels as well as for upgrading adhesion levels.	

Table 1: Use case “Set low adhesion conditions” description

1.74 UC5.1-074: DEREGISTER A VEHICLE FROM OPERATION IN THE AoC

Use case field	Description	
ID	UC5.1-074	
Use case name	Deregister a vehicle from operation in the AoC	
Main actor	Trackside Automation System (TAS)	
Other actors	<ul style="list-style-type: none"> • Railway Undertaking Supervisor (RUS) • Fleet Management System (FMS) 	
Use case summary	<p>This use case details the actions to deregister a vehicle from operation within the area of control (AoC). The vehicle will remain in the AoC but will not be further recognised as an active vehicle and can therefore not be used in operations. The deregistration takes place for maintenance in the AoC. This use case does not cover the deregistration of the vehicle for stabling as this is covered in other use cases.</p>	
Applicability	<ul style="list-style-type: none"> • Geographical: European • System level: System GoA3/4 • Operational category: passenger, urban, regional, mainline, freight 	
Main goal	<p>The main goal is to deregister a vehicle from control by the TAS within the area of operation. The vehicle is then not accessible by the TAS.</p>	
Preconditions	<ul style="list-style-type: none"> • Vehicle is registered in AoC • The vehicle is stabled and prepared for deregistration (e.g., de-energised) • The vehicle is properly secured against unintended roll away 	
Termination outcome	Successful outcomes	<ul style="list-style-type: none"> • Outcome 1: Vehicle is deregistered from AoC
	Unsuccessful outcomes	<ul style="list-style-type: none"> • Outcome 2: Vehicle cannot be deregistered
Condition affecting termination outcome	Outcome 2	<ul style="list-style-type: none"> • Vehicle is still in operation (as part of a train unit or registered consist) • Vehicle is within an area of control where deregistration is not allowed
Use case scenario	Step 1	RUS provides vehicle number for deregistration from operations to FMS
	Step 2	FMS checks if vehicle can be deregistered and sends command to TAS on deregistration of the vehicle
	Step 2.1	FMS cannot deregister vehicle as vehicle is part of a train unit in operation and informs RUS or preconditions are not met
	Step 2.2	RUS acknowledges
	Step 2.3	<ul style="list-style-type: none"> • Outcome 2: Vehicle cannot be deregistered

	Step 3	TAS checks if vehicle can be deregistered from trackside perspective
	Step 4	TAS commands usage restriction area to block occupancy of the track sections where the vehicle is located*
	Step 5	TAS deregisters vehicle and sends confirmation to RUS
	Step 5.1	TAS cannot deregister vehicle as conditions from the trackside perspective are not met
	Step 5.2	RUS acknowledges
	Step 4.3	<ul style="list-style-type: none"> • Outcome 2: Vehicle cannot be deregistered
Postcondition		<ul style="list-style-type: none"> • Vehicle is not registered in AoC
Use case notes	<p>*The usage restriction area on the track will block and mark the occupancy of the track to indicate that a vehicle is stored there providing a shadow occupancy. Train units may not be allowed to enter the occupied track sections or only with restrictions (on-sight/staff responsible). The vehicle might further be monitored through track sensors (axle counter, track circuits).</p>	

Table 1: Use case “Deregister a vehicle from operation in the AoC” description