Rail to Digital automated up to autonomous train operation

D5.6 – Documentation of urban user cases and operational rules for automation process

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REPORT CONTRIBUTORS

Name	Company	Details of Contribution
Daria Kuzmina	UITP	Led the development and execution of the T5.6 and corresponding the deliverable. Identified and defined the use cases for the deliverable, based on the analysis of operational rules and stakeholders' expectations. Coordinated of the use cases development.
Dusan Patrick Klago	Sporveien	Provided the expertise and experience of Sporveien Trikken urban operations to improve use cases and scenarios descriptions. Collaborated with other experts from UITP R2DATO WG to ensure the deliverable and use cases met the requirements and expectations of R2DATO consortium.
Nacho Celaya Vela	CAF	Supported in developing and applying a consistent and effective methodology for describing the use cases. Evaluated the technical feasibility and suitability of the implementation and parametrisation options for developing ATO tram technologies. Contributed with relevant knowledge and lessons learned from previous related projects.

EXECUTIVE SUMMARY

Tramway operational environment differs from mainline and therefore this segment has specific use cases and user requirements. Moreover, there is no common view in Europe, as each local operator has its needs in terms of use cases and operational rules. Task 5.6 of Work Package 5 collected such use cases and operational rules aiming at harmonisation following its objectives. This will pave the way for developing a harmonised solution with the aim to fit in most of the tramway systems in Europe. This collection was achieved by organising regular meetings and workshops with key European players through a specific working group derived from the Light Rail committee of UITP.

The deliverable D5.6 in the frame of the Task 5.6 has aimed to contain a set of documents defining harmonised urban use cases and operational rules for all relevant automation process subproject technical enablers: automatic functions, autonomous operations, safe perception system, remote driving and telecommand.

The methodology for collecting operational use cases (Section 2) involved several steps, including gathering existing rules and regulations from urban rail operators to serve as a foundation for shaping automation-based operational norms, analysing the compatibility of these rules with automation, and compiling a comprehensive list of potential use cases for non-commercial areas and depots. This process was repeated for commercial operational areas in a second iteration.

Operational use cases are defined by considering where automation can enhance daily operations and how tram and light rail systems should respond to environmental cues while aligning with network operational norms. Besides the input from the operators, two relevant deliverables, D2.1 from the TAURO project, focusing on remote driving and command specification, and D1.1 from the ELASTIC project, which contributed to the exercise.

Operational rules, compiled from feedback provided by tram operators, are summarised in Section 3.1, and presented in Annex 2 and 3. These guidelines encompass a range of actions and directives that tram drivers must adhere to in order to ensure the safety and efficiency of tram services. They are divided into distinct categories that address various aspects of tram operation. In Section 3.2, prioritised use cases for depots and non-commercial areas are presented, which include:

- Remote parking in depots: This serves as an intermediary step between manual tram operation and full autonomy. Implementing ATO can help tackle several challenges, such as minimising shunting time, optimising track allocation, and automating routine operations.
- Remote washing: Automating the tram cleaning process can significantly enhance its overall reliability and precision of the process.
- Pre-departure tram check: This plays a crucial role in tram operations. Partial automation and full autonomy can enhance the efficiency of pre-departure tram checks, including wheel profile examinations, remote control of tram subsystems, and autonomous tram routines.
- Autonomous shunting (from indoor to outdoor within the depot area): the use case integrates automated driving and decision-making based on the surrounding environment, addressing obstacles and weather conditions.

- Autonomous shunting of multiple vehicles simultaneously using V2X[1]: This is the most technologically advanced use case among the operators' priorities. It focuses on vehicle management, particularly the replacement of an out-of-service tram with an operational one. This requires the implementation of V2X communication, creating a comprehensive framework for information exchange among multiple trams and the surrounding infrastructure.
- Wheel profile examination: This is a highly specific use case that illustrates a particular maintenance procedure, involving laser wheel profile examinations. It demonstrates how remote driving can optimise the examination process.

In regard to commercial areas, based on operational rules, the first list of the use cases to analyse has been proposed (Section 3.2.2):

- Functional use cases: self-test, obstacle detection and speed adjustment, automated acoustic signals, real-time tram positioning, control of speed, detection of signs, signals and markings, V2X communication
- Operational use cases: tram behaviour at crossings and intersections, platform approach and stops, track control, tram coupling/decoupling.
- Infrastructure and vehicle maintenance, schedule adherence, operations involving passengers, tram behaviour in case of sub-system failures, driver interventions, and emergency response.

After the task completion, several open points need attention (Section 4):

- Specific use cases for tram operations in non-commercial areas during emergencies should be a focus for future work.
- Harmonising technologies and ATO setup in non-commercial areas is an unresolved challenge that might require standardisation and industry collaboration.
- Priority should be enhancing the advanced driving assistance system, particularly defining GoA2+ within the FP2 program.
- Further exploration of the European Union's regulatory framework and addressing ethical questions is recommended to enable autonomous tram operations, possibly through collaboration with road operators and the automobile industry.

[1] V2X communication refers to the exchange of information between vehicles and other entities, such as infrastructure, other vehicles, or pedestrians, to enhance overall safety and operational efficiency in transportation systems.

ABBREVIATIONS AND ACRONYMS

ADAS	Advanced driving Assistance System
ATO	Automatic Train Operation
D5.6	Deliverable 5.6
FP2	Framework Programme 2
GoA	Grade of Automation
HMI	Human-Machine Interface
HV	High Voltage
HVAC	Heating, ventilation, and air conditioning
OCC	Operations Control Centre
R2DATO	Rail to Digital automated up to autonomous train operation
RFID	Radio Frequency Identification
TCMS	Train Control and Monitoring System
V2X	Vehicle-to-Everything
WP	Work Package

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1 INTRODUCTION

The integration of automation and autonomous operations in tram and light rail networks holds significant promise for optimising various aspects of urban rail operations. Regarding the tram and light rail systems, in order to reveal the benefits of the deployment of ATO systems across diverse operational contexts, the definition of appropriate use cases is a necessary step. Over a span of 12 months, WP5 Task 5.6 "Documentation of Urban Use Cases and Operational Rules for Automation Process" executed this collection through a series of regular meetings and workshops involving key European stakeholders. These engagements were facilitated by a dedicated working group established from the Light Rail committee members of UITP (International Association of Public Transport).

The group of urban rail operators identified several key advantages:

- Streamlining routine tram operations: automation is practiced at overseeing repetitive tasks like shunting, washing, and self-diagnostics within depot and non-commercial areas where public access is restricted. This not only increases efficiency but also minimises human intervention in everyday operations.
- Revitalising depot management: ATO systems offer the potential not only to operate the tram fleet within depots efficiently but also to redefine the perspectives on personnel roles and responsibilities. Confronting the challenges of workforce scarcity, ATO can facilitate the diversification of personnel tasks and the introduction of innovative roles like remote tram operators. This multi-pronged strategy optimises the utilisation of available resources.
- Enhancing Safe and Efficient Tram Operation: ATO systems are designed to provide comprehensive support for tram operators, ensuring safe and efficient driving during regular operations, while still retaining the role of the driver for critical decision-making.
- Optimising energy usage by providing best driving technique: ATO system can be engineered to provide real-time feedback and assistance to tram operators in adopting the most energy-efficient driving techniques. By constantly monitoring factors such as acceleration, braking, and speed control, ATO systems help tram operators make decisions that reduce energy consumption.

Task 5.6 focuses on addressing the challenges of tramway operational environments, distinct from mainline operations. This difference arises from the specific use cases and user requirements applicable to trams. Notably, there is no unified perspective across Europe, as each local tram operator has their own instructions and regulations but also distinct needs in terms of use cases and operational rules.

The deliverable D5.6 in the frame of the Task 5.6 has aimed to develop a document defining harmonised urban use cases and operational rules for all relevant automation process subproject technical enablers: automatic functions, autonomous operations, safe perception system, remote driving and telecommand.

To address this diversity, Task 5.6 undertook the collection of varied use cases and operational rules with the goal of achieving harmonisation. This harmonisation effort is crucial for developing a standardised solution capable of accommodating the majority of tramway systems across Europe.

The outcomes of Task 5.6 are delivered in this deliverable, D5.6 “Documentation of urban user cases and operational rules for automation process” which contributes to other Work packages of R2DATO, namely:

- WP6, which centres around Automation Process Specifications. WP6 aims to specify functions for trams, encompassing ATO technology solutions for trams, on-board systems, and the ATO Control Centre. The use cases developed in Task 5.6 provide valuable input to the function list defined in WP6.
- WP7, which focuses on GoA3/4 Data Factory Specifications and Implementation. Within this context, Task 5.6 contributes by identifying potential data requirements for the data factory, ensuring that the necessary data is available for project purposes.
- WP8, dedicated to Safety Analysis & Risk Assessment. Specifically, it contributes by providing use cases related to emergency and out-of-ordinary procedures, which are crucial for safety assessments.
- WP40, WP41 and WP 42 the Tram Demo work packages, which aims to demonstrate R2DATO some tram functionalities. The documentation of use cases and operational rules in Task 5.6 directly supports the objectives of WP40 by providing the foundation for showcasing R2DATO tram functionalities during the demonstration.

Section 2 of the deliverable explains the methodology applied for generating the operational rules and use cases. It also includes analysis of existing and relevant deliverables from the relevant projects, use case template, definitions and actors used in the use case descriptions. Section 3 describes operational rules (section 3.1) and use cases (section 3.2). Open points not covered by the work of Task 5.6 is presented in Section 4. It contains recommendations for further research. And, finally, conclusions and recommendations of the work are presented in Section 5.

The process of describing operational use cases is a time-intensive activity, requiring technical and operational understanding, awareness of regulatory constraints, and adjustments for feasibility. In the methodology proposal for task 5.6, limitations include prioritising non-commercial operational environment, with a focus on feasibility and significant benefits while setting aside use cases with limited implementation potential or those addressing emergency situations due to ethical and legislative constraints. These limitations align with R2DATO's primary focus on tram demonstrations (WP40, 41 and 42).

2 METHODOLOGY

2.1 INTRODUCTION INTO METHODOLOGY

The primary objective of Task 5.6 is delivering use cases and operational rules aiming at their harmonisation due to different operational environments and order of the various urban rail operators in Europe. The deliverable D5.6 has aimed to contain a set of documents defining harmonised urban use cases and operational rules for all relevant automation process subproject technical enablers: automatic functions, autonomous operations, safe perception system, remote driving and telecommand. The methodology for collecting such use cases involves several steps.

1. Existing operational rules for non-commercial areas and depots were collected from several urban rail operators, cataloguing existing operational regulations and practices, serving as the foundation ("as-is situation") upon which automation-based operational norms were shaped. They included norms, rules, instructions, procedures, and regulations that were analysed and harmonised.
2. A subsequent analysis determined the compatibility of existing rules with the introduction of automation.
3. The bottom of the operational use case definition phase was the compilation of a comprehensive list of potential use cases catering primarily to non-commercial areas and depot environments.
4. Then these operational rules were transformed to the use cases, leading to the compilation of a comprehensive list of potential use cases catering primarily to non-commercial areas and depot environments.
5. Besides it, existing and relevant deliverables from the partner projects, as well as other research and innovation projects on tram automation were analysed in order to deliver the full list of use cases, ready for prioritisation and elaboration.
6. In the second iteration, the same process was performed for commercial operational areas.

The methodology involves a collaborative approach, with input from the working group members and experts in the field of tram automation, as well as from other relevant projects. The goal was to identify use cases that are practical and achievable in the short term, while still considering longer-term objectives and innovations in the field.

The selection of use cases and their priority arrangement by operators was characterised by a straightforward criterion: the necessity to address the principal inquiry, "How might the implementation of automation within tram systems yield the most significant benefits, and where could automation be advanced faster?" In the latter context, unanimous consensus among operators emerged, highlighting the comparative ease associated with introducing automation within restricted zones, such as depots, workshops, and shelters. Such deployment frequently obviated the necessity of city or state-level approvals, or engagement of external stakeholders that might slow down the process of the deployment. Moreover, this presented a worthy opportunity to evaluate the efficacy of the automation solution, acclimate personnel to its usage, all without necessitating legislative modifications.

As here and further in the text different terms are used, below difference between operational rule, functional use case and operational use case are clarified.

What is an operational rule?

The term operational rule in this deliverable refers to the existing norms, instructions and rules that regulate the operations of tram and light rail systems by various operators. Since these rules may differ among operators, this report aimed to group them into general high-level categories that are important for the deployment of ATO and autonomous operations or that should not be overlooked when they are deployed. In short, the operational rules represent the current state-of-the-art of how the operations are conducted without an ATO.

What is a functional use case?

A functional use case in this deliverable is defined a detailed description of a specific interaction with or within a system that illustrates how the system responds to inputs and performs specific tasks or functions to achieve a particular objective. One of the examples of the functional use cases defined in Annex 4 are: connecting to the vehicle, establishing remote driving mode, telecommand: turning off the vehicle.

What is an operational use case?

An operational use case is a comprehensive representation of how a system operates in the real-world context, focusing on the system's behaviour and interactions with external entities, such as users, other systems, or hardware components, to accomplish its primary objectives. Unlike functional use cases that describe specific functions or features in isolation, operational use cases provide a broader view of how the system functions within its environment, considering various scenarios, user roles, and system states.

Operational use cases are established by addressing two key questions:

1. Contextual Automation: where can automation meaningfully enhance daily operations?

2. Operational Behaviour: how should trams and light rail systems behave in response to environmental cues and aligned with the network’s operational norms?

The former question concerns instances where automation, remote driving, or autonomous operations can succeed the role of an onboard driver or provide the drivers an advanced support. The latter concerns to harmonising operational use cases, thereby enabling the smooth integration of decision-making processes facilitated by automation.

The primary objective of D5.6 centres on the description of operational use cases. These use cases serve a dual purpose: first, to provide a comprehensive framework for the application of automation; and second, to capture the surrounding ecosystem, encompassing constraints, norms, and the conduct of trams and various other stakeholders.

The process of describing operational use cases is a time-intensive activity that necessitates an understanding of what is technically and operationally achievable, awareness of regulatory constraints, and a grasp of the necessary adjustments to achieve feasibility. Consequently, in the initial stages of the methodology proposal, we established the following limitations for the framework of R2DATO:

1. Priority to use cases in non-commercial operational domains closed for general public and other road users. This prioritisation aligns with the primary focus of R2DATO tram demonstrations.
2. Emphasis on feasibility and benefits: an attention is given to use cases that offer the most significant benefits and are relatively easier to implement. Conversely, use cases with limited implementation potential or those associated with addressing emergency situations are set aside for future. This decision is driven by ethical and legislative considerations, as such scenarios often require human presence and decision-making, and deployment of such use cases is not possible at this stage of the technology development.

2.2 EXISTING AND RELEVANT DELIVERABLES FROM RELEVANT PROJECTS

Two deliverables from two different projects have been highlighted as relevant for the scope of urban rail automation and autonomous operations:

1. The TAURO (Technologies for Autonomous Rail Operation) project, with grant agreement No: 101014984, was funded by Shift2Rail, which is now known as Europe's Rail and is the predecessor of the R2DATO project. The analysed deliverable from this project is D2.1, which focuses on the specification of remote driving and command.
2. The ELASTIC (A Software Architecture for Extreme-Scale Big Data Analytics in Fog Computing Ecosystems) project received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No: 825473. The deliverable under analysis from this project is D1.1, which relates to the specification and definition of use case requirements.

2.2.1 Relevant functions

The following functions outlined in the deliverables have been identified as relevant to Task 5.6 and its use cases:

1. TAURO – Functions related to a remote control:
    - Provide external view for train operation (in any weather / light conditions);
    - Clean the windscreen;
    - Defrost the windscreen;
    - Provide common interior lighting;
    - Manage HVAC mode;
    - Manage surveillance sources;
    - Release external doors;
    - Enable release external doors;
    - Cancel release external doors;
    - Open external doors;
    - Close external doors;
    - Manage sanding;

- Manage cab control;
- Initiate diagnostics;
- Indicate presence by acoustic means;
- Indicate the presence by external lights;
- Manual application/release of the parking brake.

2. TAURO – functions related to driving:
   - Acquire brake demand;
   - Manage operation mode;
   - Manage shut down mode;
   - Manage standby/service retention configuration;
   - Manage in service mode;
   - Manage driving mode;
   - Manage propulsion & brake demand;
   - Manage energy supply.
3. TAURO – functions related to displaying and providing the information:
   - Display surveillance information;
   - Provide operation relevant information;
   - Manage control of the train parameters;
   - Access diagnostics data;
   - Display information for control;
   - Display information for monitoring;
   - Display information for diagnostic;
   - Display information for maintenance.

4. TAURO – functions related to perception and monitoring:
   - Manage appropriate and safe conditions;
   - Manage test results;
   - Manage events according to their priority;
   - Allow detailed event analysis;
   - Provide guidance to the driver to continue the mission;
   - Monitor obstacles within track.

Other functionalities that were out of the scope for the use cases for non-commercial areas, as well as some functions related to emergency situations, are presented there for backlog purposes:

- Provide Public Address;
- Manage emergency alarm from passengers;
- Isolate external doors;
- Ensure passenger access by external doors for people with reduced mobility;
- Manage coupling;
- Manage uncoupling;
- Manage electrical energy for traction;
- Collect electrical energy for traction;
- Manage electrical auxiliary energy provisioning;
- Acquire propulsion demand;
- Manage traction system within mode;
- Isolate braking systems/devices;
- Acquire information to be displayed;
- Ensure display of information;
- Manage energy saving mode;
- Manage battery protection mode;
- Manage access and loading;
- Manage integration of the vehicle in the complete railway system;
- Manage manual test;
- Manage troubleshooting text;
- Configure parameters of Control driver activity device;
- Provide test of Control driver activity before departure;
- Isolate driver activity device.

5. Based on the requirements identified in Elastic project, the following functionalities can be highlighted:
    - Monitoring and reading the tags (e.g., RFID) to trigger actions that the on-board system shall perform when the vehicle enters a «critical» area;
    - Auto-connection and re-connection in case of disconnection to the network's WI-FI;
    - Autonomous positioning;
    - Obstacle detection;
    - Weather/visibility analysis;

- Location analysis (e.g., manoeuvring area, shelter, platform surroundings, crosswalk, line sides, crossroad, etc.).

2.2.2 Related use cases

These are functional use cases delivered within TAURO project that were defined as relevant for the Task 5.6:

1. Manage communication.

- The OCC manages communication between the groundside and a selected tram within the depot using the tram's serial number.
- This use case includes three lower-level use cases:
  - Establish connection;
  - Initiate data communication;
  - Perform video streaming;
  - End connection.

2. Provide proper conditions.

- The OCC commands the activation of one tram to take control of a cab within the selected tram.
- This use case covers functionalities and interactions to establish proper conditions for OCC to control the cab.
- Lower-level functional use cases include:
  - Switch on the tram;
  - Enable the cab;
  - Set "remote driving" mode;
  - Provide energy for traction and auxiliaries (including managing the current collector and HV electric equipment);
  - Manage doors.

3. Move the tram.

- This use case involves driving the tram, including acceleration, braking, video monitoring, and protections.
- Lower-level functional use cases include:
  - Accelerate;
  - Control driver activity;
  - Detect obstacles (CDWS - Collision Detection and Warning System);
  - Decelerate;
  - Provide proper visibility (including wipe & wash, defrost & demist);
  - Monitor cameras;

- Warn acoustically;
- Manage external lights;
- Select destination.

From Elastic project, two main use cases related to driving can be highlighted:

1. Detection of various objects.

This use case focuses on detecting various objects, including:

- Static harmful and harmless obstacles between the rails of different heights;
- Moving obstacles of different sizes along the rail;
- Obstacles moving at a distance from the tram, with trajectories and speeds that could lead to future collisions;
- Recognition of concrete objects such as humans, children, dogs, bicycles, motorbikes, cars, trams, buses, lorries, horses, and horse-drawn carriages.

2. Controlling the different speeds at various operation environments.

This use case addresses controlling tram speeds in different operational environments, including:

- Moving in city areas crowded with people or various types of vehicles;
- Moving around platform areas;
- Moving along straight or curved track sections;
- Moving near crossings with traffic lights and vehicles, as well as pedestrian crossings;
- Moving along streets with parked cars and pedestrians on pavements;
- Moving near other stationary trams or trams moving in the opposite direction.

2.3 USE CASE TEMPLATE AND DEFINITIONS

This section presents the template for use cases, which is provided in Annex 1 and definitions of the terms used in it. The use cases template was developed to capture and document the potential use cases for tram and light rail operations with ATO and autonomous manoeuvres. These use cases represent the steps involved in different defined by T5.6 scenarios of such operations. The definitions aim to ensure a common understanding and consistency of terminology among the authors and readers of this deliverable.

2.3.1 Definitions and Actors

The definitions mentioned below were formulated in the framework of Task 5.6 in order to clarify elaborated use cases.

Remote driving: The operation of a vehicle from a location removed from the vehicle itself. In this context, it typically involves controlling a tram from a remote operation room within the depot.

Telecommand: The process of remotely controlling or commanding a tram, which may include actions like managing the HMI of the tram cab or controlling tram equipment from a remote location.

Automated vs Autonomous: "Automated" refers to a system or process that performs tasks or functions with little to no human intervention, following pre-planned procedures. In contrast, "autonomous" implies self-governance and decision-making capabilities without direct human control.

Commercial runs area: Designates scheduled tram services operating in mixed, open traffic conditions.

Non-commercial area: An area within the tram network restricted to public access, primarily used for fleet maintenance and parking.

Control centre operator (OCC): An individual responsible for monitoring and managing tram operations. The OCC may also oversee tram operations in non-commercial areas, such as depots, if this role is not fulfilled by the local operations management room within the depot (see below).

Operations management room: A designated area within a depot facility where tram movement activities, including management and coordination, are conducted.

Tram remote driver-operator: An individual who remotely operates a tram from a control room, managing its functions and movements.

Supervising system: An onboard or side-track add-on system that ensures the safety of tram movements, particularly in remote or autonomous modes of operation.

Traffic manager: A member of the OCC responsible for traffic management within the commercial area of the tram network.

TCMS-HMI: TCMS stands for Train Control and Monitoring System, and HMI stands for Human-Machine Interface. TCMS-HMI refers to the interface or display used by tram drivers to control and monitor tram functions.

RTS – Ready to Start: The state of a tram vehicle indicating that it is prepared and in the appropriate condition to begin operations.

V2X, "Vehicle-to-Everything," a communication technology that enables vehicles to exchange information with other vehicles, infrastructure, pedestrians, and other connected devices to enhance safety and traffic management.

3 OPERATIONAL RULES AND USE CASES

3.1 OPERATIONAL RULES

3.1.1 Depots and non-commercial areas

The compilation of operational rules, sourced from tram operators and summarised at a general level, is presented in Annex 2. These norms cover the required actions and protocols incumbent upon tram drivers to ensure the secure and efficient operation of tram services. The operational rules have been classified into four distinct activity categories, each elucidating different facets of tram operation:

- **General operational rules:** These encompass all activities associated with communication between tram operations and the OCC or operations management room of a depot[2]. This category contains procedures such as incident reporting, permission requests, and instruction reception. Furthermore, it addresses protocols to be followed in the event of OCC evacuation or changes in signals and signage, necessitating the use of alternative communication channels and the activation of emergency procedures.
- **Operational rules before starting up:** This category includes rules concerning the pre-departure driver's checklist, a comprehensive set of checks and assessments mandated prior to tram commencement. These checks encompass an evaluation of the tram's condition, the reporting of defects and malfunctions, the activation of the vigilance device (Deadman function), and the initiation of the Automatic Vehicle Location System (AVLS).
- **Operational rules for start and control:** Following the completion of the pre-departure checklist, this category outlines actions relevant to selecting the appropriate cab, driving mode, and route. It also includes procedures governing tram movements within depots and workshops, including the requirement of clearance acquisition from the OCC, track and points inspections, and the utilisation of acoustic signals. Additionally, it encompasses checklists for drivers prior to moving within or outside the workshop, procedures for entering or exiting the workshop, and the inspection of track obstacles before commencing operations.
- **Operational rules for driving**: Applying to tram operation within non-commercial areas, this category encompasses several facets. These include the recognition and adherence to signals and signage, compliance with speed principles and limitations adequate to environmental conditions, communication with the OCC during operation, selection of appropriate tram cab key modes, identification of factors influencing acceleration and braking capacity, and the adaptation of driving techniques accordingly. Moreover, it outlines procedures for manoeuvres such as tram turning within depots, the tram washing process, and handling movements in the incorrect direction. This category also emphasizes driver behaviour during operation, including ensuring proper visibility, utilisation of acoustic signals when warranted, vigilance regarding track-adjacent or onboard obstacles, and the precise control of traction and braking.
- **Operational rules after parking:** This final category governs actions to be taken subsequent to tram parking.

The identification of these operational rules establishes a pivotal mission within the project, as they set out the parameters and range of opportunities for ATO. For instance, certain rules may be executed autonomously by ATO systems, while others necessitate the physical presence of the personnel. These rules control over the circumstances and locations in which a driver can be replaced by remote and ATO systems, or support the driver, and those where such substitution is inadvisable. Subsequently, within this deliverable, these operational rules are seamlessly integrated into the description of defined operational use cases, deemed most suitable for non-commercial tram operation areas, looking at the same time how the existing operational rules can be modified so ATO system could take over existing performed by humans' activities more efficiently.

[2] From here and further to simplify the text, only the term OCC will be used.

3.1.2 Commercial context

In the process of gathering operational guidelines for non-commercial areas, the operational rules for commercial ones were in parallel gathered and consolidated in a generalised manner. The compilation is presented in Annex 3. It is important to note that, owing to the project's constraints in terms of time and the primary emphasis on the depot environment, given the demonstrations focused on the depot areas, the intention was not to comprehensively collect all conceivable operational rules. Rather, the objective was to establish a robust foundation for the continuation of this endeavour in the subsequent project of the programme. This involves the enhancement of defined operational rules with greater detail, with a specific emphasis on network characteristics that can subsequently be extrapolated into parameters for the ATO system.

To summarise the operational rules collected for the commercial urban context, the following key categories can be highlighted based on activity groups:

- General:
    - Rules for responding to emergency situations, such as deviations from typical tram behaviour, damage to infrastructure or vehicle subsystems, and the presence of objects on tracks – some of the situations necessitate personnel intervention.
    - Procedures for automated self-maintenance and self-diagnosis, including the use of sand and notification of system failures.
    - Prioritised actions for safety, including voice communication, intercom usage, and communication in tunnels.
- Before start:
    - Instructions for operating doors, including forceful closure.
- Start and control:
    - Rules for initiating vehicle operations from specific network locations, such as platforms, depots, and terminus points
    - Route selection protocols.
- Driving:
    - Guidelines for maintaining awareness of the tram's surroundings while it is in motion.
    - Procedures for moving trams with failures and/or those taken out of service.
    - Driving techniques and recommended speeds, including approaches to specific infrastructure objects, crowd management, interpretation of signs and signals, and object identification.
    - Actions to take in the event of driving errors.
    - Response protocols for unexpected objects on the tracks during motion, such as people and animals.
    - Procedures for handling accidents involving vehicles, pedestrians, and passengers both inside and outside the vehicle.
- Parking and after-parking:

- Rules governing the positioning of trams at platforms;
- Protocols for emergency stopping;
- Management of tram doors.

3.2 USE CASES

3.2.1 Depots and non-commercial areas

In collaboration with representatives from public transport operators, we have identified and classified two distinct categories of use cases for ATO tram systems, outlined in Section 2.1. Specifically, we have chosen to place a largest emphasis on the operational use cases, aligning with the objective of this deliverable.

Operational use cases offer a more robust and compelling demonstration of the advantages and potential inherent in automated and autonomous tram and light rail operations in real operation context, considering all limitations and regulations.

Furthermore, the process of producing these use cases has proven important in guiding towards a prioritisation of use cases. Through their development, we have been able to discern the relative importance and feasibility of various operational scenarios. On the contrary, functional use cases have a more abstract and generic perspective, showcasing concrete isolated functionalities.

The full list of use cases for deports and non-commercial areas is available in Annex 4.

For this deliverable six use cases were defined as a priority for the depot environment that covering and showcasing the majority of the functionalities of ATO systems, including remote driving, telecommand and autonomous operations.

1. **Use case UC.5.6.5.24: Remote parking in a depot**

General context

Shunting in a tram depot is the process of moving trams between tracks or on the same track, usually for parking, maintenance, or washing purposes. Shunting may involve switching points, signals, and crossings to ensure the safe and efficient movement of trams within the depot. Application of ATO (both remote driving and autonomous operations) can address the following challenges: minimising the shunting time, optimising the track allocation, automating the routine operations, etc.

Use case field	Description
ID	UC.5.6.5.24
Use case name	*Remote parking in a depot*
Main actor	*Tram remote driver-operator (remote operator)*
Other actors	• *Control centre operator or operations management room (at the depot) (OCC)* • *Supervising system*

	• *Depot personnel*	
Use case summary	*This use case involves the OCC granting permission to a remote operator to park a tram remotely on a vacant track and spot. The remote operator connects to the tram, selects the destination track and spot, commands the tram to move at shunting speed, and monitors the tram's movement until it reaches its final position and comes to a stop.*	
Applicability	• *Geographical: Europe* • *Operational category: Urban*	
Main goal	*The primary objective of this use case is to park a tram safely and efficiently on a designated depot track and spot using remote control while adhering to all safety and operational rules.*	
Preconditions	• *The tram is in a ready state for remote operation.* • *Communication between the remote-control centre and the tram is established.* • *Supervising systems (both onboard and trackside) are activated.*	
Termination outcome	**Successful outcomes**	• *The tram is successfully parked in the designated position.* • *All communications and systems are properly deactivated.*
	Unsuccessful outcomes	• *Communication failure between the remote-control centre and the tram.* • *Safety violations or faults detected during tram movement.*
Condition affecting termination outcome	**Outcome 2**	• *If communication fails, the tram may need to make repeated attempts to reconnect, following the operational rules of the network operator.* • *Safety violations or faults must be reported to the OCC.*
Use case scenario	**Step 1**	*The tram is locally started up. Tram systems are powered on, and initial checks are performed to ensure readiness for remote operation.*
	Step 1.1	*Initial checks reveal system failures, preventing remote driving. The operation cannot proceed successfully, and appropriate actions, such as reporting the issue and halting the operation, must be taken.*
	Step 2	*The remote operator initiates the remote driving mode, selecting the specific tram vehicle to be moved remotely and configuring the desired route and destination. They then contact the OCC to confirm the procedure. After receiving confirmation, the OCC*

	manages motorized points along the route, allowing the remote operator to proceed with the next steps.
Step 2.1	*If confirmation of communication receipt is not If the remote operator does not receive confirmation of communication receipt from the OCC, they must halt further actions and attempt to reconnect with the OCC following the network instructions.*
Step 3	*The remote operator activates the tram's onboard sensors, included in the perception system, and initiates video streaming. This step ensures proper visibility by verifying elements such as window cleanliness, camera views, and defrost functions.*
Step 3.1	*If proper visibility is not ensured, a manual check must be performed, and Step 3 must be repeated.*
Step 4	*The remote operator performs a pre-driving self-check on the tram following instructions for tram preparation for moving trams inside or outside the workshop, ensuring safety and operational readiness. They check remotely for:* • *Power is on.* • *Red light is illuminated.* • *The crane is not in the way (via cameras).* • *No person is working on or near the tram (via cameras).* • *The tram is not coupled to another tram.* *Checked manually by the depot personnel:* • *No scotches under wheels.* • *Body catchers are raised.* • *All panels are secured.*
Step 4.1	*Any defects or faults identified during this check are reported to the OCC immediately. The use case is not further performed.*
Step 5	*The remote operator verifies the current position of the tram and attentively observes its surroundings through video cameras while checking sensors.*
Step 6	*After making sure supervising systems are activated, the remote operator chimes (or using a bell) remotely and commands the tram to start moving. The operator uses remote controls to manage the tram's speed and maintain a safe following distance. Continuous monitoring of the tram's movement is performed, with*

	real-time feedback from sensors, cameras, and communication systems. The maximum speed does not exceed the shunting speed.
Step 6.1	*If the operator notices an object on the tracks that prevents the completion of the route, they must initiate braking or emergency braking, depending on the situation. If the remote operator does not perform this procedure, the system initiates automatic emergency braking. After the obstacle is removed, the remote operator must repeat Step 6.*
Step 6.2	*If the obstacle is not removed or not possible to remove, the remote operator must contact OCC to follow the instructions.*
Step 7	*The remote operator checks signal statuses and signs using the cameras, adjusting speed, or applying brakes when necessary.*
Step 8	*When the tram's parking spot is inside the workshop, the remote operator, using the remote control, stops before the door, chimes remotely, checks for obstacles on the tracks or in the yellow zone, and if it's safe, proceeds inside.*
Step 8.1	*If the operator notices an object on the tracks that prevents the completion of the route, they must initiate braking or emergency braking, depending on the situation. If the remote operator does not perform this procedure, the system initiates automatic emergency braking. After the obstacle is removed, the remote operator must repeat Step 8.*
Step 9	*The tram reaches its designated track and spot (Track B), and the remote operator stops it at the designated position using deceleration. The system monitors maximum shunting speed.*
Step 9.1	*If the obstacle is not noticed by the remote driver, and they didn't stop in timely manner, the system initiates emergency braking.*
Step 10	*The remote operator sends a confirmation signal to the OCC, indicating the successful completion of the movement. The signal must be confirmed by OCC.*

	Step 11	*The remote operator deactivates the sensors, cameras, and communication systems. A communication confirmation is exchanged between the remote operator and the tram to acknowledge the completion of the remote parking process. The process concludes with all systems properly switched off, and communication is concluded.*
	Step X	*If, at any point during the process, an unsuccessful communication confirmation or safety violation is detected, the process will branch to the common outcome labelled as 'X.' Outcome 'X' signifies that the operation cannot proceed successfully, and appropriate actions, such as reporting the issue to the OCC and halting the operation, will be taken.*
Postcondition	*The tram is parked in the designated position.* *All communication and systems are deactivated.*	
Use case notes	*This use case outlines the procedures and rules for safely remotely parking a tram within a depot, ensuring compliance with safety and operational guidelines.* *This Use Case has the following links with the operational rules (Annex 2):* • *OR.00.01 Communication with OCC* • *OR.00.02 End of communication with OCC* • *OR.00.05 Reporting defects and faults* • *OR.01.02 Vigilance device (Deadman function) activation/deactivation* • *OR.02.02 Tram movements in depots and workshops* • *OR.02.03 Driver check list before moving inside or outside the workshop* • *OR.02.04 Actions to do if power is off before entering or leaving the workshop* • *OR.02.05 How to enter/exit workshop after driver checklist* • *OR.02.06 Controlling motorized points within depots* • *OR.02.07 Track obstacles check before driving* • *OR.03.01 Recognising signals* • *OR.03.02 Recognising signs* • *OR.03.05 Tram cab key control modes* • *OR.03.07 Speed limits* • *OR.03.09 Turning trams in depots* • *OR.03.12 Check proper visibility* • *OR.03.13 Acoustic signal before driving* • *OR.03.14 Detect obstacle (object in the or near track)* • *OR.03.16 Event of unintended train separation*	

	• *OR.03.17 Braking in the event of derailment*

Table 1: Use case "Remote parking in a depot" description

2. UC.5.6.5.25: Remote washing

General context

The operators identified a second opportunity, which involved the application of automation and remote-control technology to streamline the tram washing routines. This approach aimed to improve efficiency by allowing operators to control and monitor the washing process of exterior remotely. By implementing automation, they could enhance the overall reliability and precision of tram cleaning operations. Ultimately, this initiative sought to optimise resources and deliver a more cost-effective and consistent tram maintenance solution.

Use case field	Description
ID	UC.5.6.5.25
Use case name	*Remote washing*
Main actor	*Tram remote driver-operator (remote operator)*
Other actors	• *Control centre operator or operations management room (at the depot) – OCC* • *Depot personnel*
Use case summary	*The remote tram washing process allows a tram to be washed remotely with approval and instructions from the OCC. The process involves establishing a connection with the tram, obtaining approval for washing, receiving pre-wash instructions from the OCC, performing manual actions on the tram, such as closing windows and hatches, moving to the washing point, undergoing the washing process, using chimes (or bells) for visibility upon exit, and receiving post-wash instructions from the OCC. If the tram stops during the process, the wash stops automatically and requires reset by the OCC.*
Applicability	• *Geographical: European level (national level, which countries? / European level)* • *Operational category: Urban*
Main goal	*The main goal of this use case is to facilitate the automated remote washing of trams while adhering to specific pre- and post-wash instructions, ensuring the safety and cleanliness of the tram.*
Preconditions	• *Communication between the remote operator and the tram is established.* • *Pre-wash instructions (operational rules) from the network operator are known.*

Termination outcome	**Successful outcomes**	• *The tram completes the washing process.* • *Post-wash instructions are received and followed.*
	Unsuccessful outcomes	• *The tram stops during the washing process.* • *Pre-wash instructions are not received by the OCC.* • *Post-wash instructions are not received or followed.*
Condition affecting termination outcome	**Outcome 2**	*Where relevant, if the tram or a washing equipment stops during the washing process, manual intervention is required, and the wash process stops automatically until reset by the OCC.*
Use case scenario	**Step 1**	*The remote operator contacts OCC to request washing approval, which is subsequently granted.*
	Step 1.1	*If the request is not approved, the procedure must be halted, and instructions from the OCC must be followed.*
	Step 2	*The remote operator, with assistance from depot personnel, prepares the tram for the washing procedure according to the network's operational rules. Some actions, such as closing windows and hatches, are manually performed on the tram by depot personnel.*
	Step 3	*After receiving approval and completing necessary preparations, the remote operator remotely moves to the washing point at shunting speed.*
	Step 4	*Before entering the washing workshop, where a green light indicates that the overhead catenary system is off or blank, the remote operator stops the tram and contacts OCC to turn on the overhead catenary system.*
	Step 5	*The tram undergoes the washing process until it is complete.*
	Step 5.1	*If the washing process is not completed, the OCC must be contacted, and manual intervention is required.*
	Step 6	*The emergency lights are activated automatically when the tram is in remote driving mode (for all relevant use cases, all the time while the tram remote connection is turned on). After using chimes (or bells) remotely, the remote operator exits the wash.*

	Step 7	*The remote operator carries out post-wash instructions in accordance with the network's operational rules and instructions from the OCC, such as parking in a specific spot.*
	Step 8	*The remote operator performs the disconnection and switches off the remote driving mode.*
	Step X	*If an unsuccessful communication confirmation or safety violation is detected at any point during the process, the operation will branch to the common outcome labelled as "X." Outcome "X" signifies that the operation cannot proceed successfully, and appropriate actions, such as reporting the issue to the OCC and halting the operation, will be taken.* *Safety precautions are based on three pillars:* • *Speed detection and regulation.* • *Obstacle detection and decision-making.* • *Leaving the remote-driving zone.*
Postcondition	*The tram has completed the washing process.* *All post-wash instructions have been followed.*	
Use case notes	*This process outlines the procedures and rules for remotely washing trams, including communication, manual actions, and compliance with pre- and post-wash instructions, while ensuring safety and cleanliness.* *The operational rules linked to the use case are (Annex 2):* • *OR.00.01 Communication with OCC* • *OR.00.02 End of communication with OCC* • *OR.00.05 Reporting defects and faults* • *OR.01.02 Vigilance device (Deadman function) activation/ deactivation* • *OR.02.02 Tram movements in depots and workshops* • *OR.02.03 Driver check list before moving inside or outside the workshop* • *OR.02.04 Actions to do if power is off before entering or leaving the workshop* • *OR.02.05 How to enter/exit workshop after driver checklist* • *OR.02.06 Controlling motorized points within depots* • *OR.02.07 Track obstacles check before driving* • *OR.03.01 Recognising signals* • *OR.03.02 Recognising signs* • *OR.03.03 Speed principle* • *OR.03.05 Tram cab key control modes* • *OR.03.07 Speed limits* • *OR.03.10 Washing procedure*	

	• *OR.03.12 Check proper visibility* • *OR.03.13 Acoustic signal before driving* • *OR.03.14 Detect obstacle (object in the or near track)* • *OR.03.17 Braking in the event of derailment*

Table 2: Use case "Remote washing" description

3. UC.5.6.10.5: Pre-departure tram check

General context

Pre-departure readiness encompasses diverse applications of ATO, including:

- Automated pre-departure checks: leveraging ATO to execute elements of pre-trip checks traditionally performed by tram drivers or depot personnel. One of the examples of such use cases is wheel profile examination (See the use case described below).
- Remote tram system control: enabling telecommand manipulation of tram systems such as doors, HVAC, and acoustic signals.
- Autonomous depot driving: facilitating autonomous tram movement within depots, fostering efficient tram deployment at the start of shifts.

Use case field	Description
ID	UC.5.6.10.5
Use case name	*Pre-departure tram check*
Main actor	*Tram remote driver-operator (remote operator)*
Other actors	• *Control centre operator or operations management room (at the depot) (OCC)* • *Supervising system* • *Depot personnel* • *Tram driver* • *Traffic manager*
Use case summary	*The "Pre-departure tram check" use case involves preparing a tram for departure by following a checklist defined by the network operator. It includes verifying safety equipment, manual checks by personnel, and self-checks of various tram systems. The goal is to ensure that the tram is in a safe and operational condition before departure.*
Applicability	• *Geographical: Europe* • *Operational category: Urban*
Main goal	*The main goal of this use case is to ensure that a tram is in a safe and operational condition before departing on its route. This includes verifying safety equipment, conducting manual checks, and performing self-checks of tram systems.*

Preconditions	• *The tram is in a state ready for pre-departure checks in remote (telecommand) mode.* • *Communication between the tram and remote is established.*	
Termination outcome	**Successful outcomes**	*The tram successfully passes all pre-departure check and ready for the shift approaches the end of the depot area/beginning of traffic area*
	Unsuccessful outcomes	• *The tram fails any of the pre-departure checks and unable to proceed for operation.* • *Communication between the tram and remote operator is disrupted.*
Condition affecting termination outcome	**Outcome 2**	*If the tram fails any of the pre-departure checks, further action may be required to rectify the issues before departure, or the tram must be substituted.*
Use case scenario	**Step 1**	*Set the tram to "P" mode to prepare for the pre-departure checks.*
	Step 2	*Safety Equipment and Seals Check.* *The depot personnel must verify that all safety equipment and seals are present.*
	Step 3	*Remote pre-departure check* • *Remotely switch to "NM" mode and follow the pre-departure checklist defined by the network operator.* • *Automatically perform checks on various tram systems: external lights, chimes & horns, interior lights, wipers & washer, passenger announcement system, doors open and close, safety brake, track brake, console indicator lamps, traction, mirror cameras, pantograph status, and control of alarms on TCMS-HMI monitors or alarm lamps on driver desk.*
	Step 3.1	*If any system of the tram doesn't work properly then this information is sent immediately to remote operator to take an action.*
	Step 4	*Manual pre-departure check* *Depot personnel conducts manual checks on all safety equipment and seals being present, saloon (visual check, i.e., floor is clean, dry and clear of any obstructions, emergency handle covers in place, overhead panels are secure, and inspect widows for defects, seal on the first aid kit box, seal on fire extinguisher, if switch iron for manual operation of the*

	switches is on place, inside of the vehicle for graffiti and damages), outside of the vehicle for graffiti and damages.
Step 5	*Pre-movement checks* *Before every movement, the remote operator must ensure the visibility: check defrost function, camera views, and sensors.*
Step 6	*Change the driving mode.* *After the remote pre-departure check is completed, the remote operator must conclude remote control session. The tram driver must turn on the tram cab locally from the tram.*
Step 6	*Contact OCC to request permission to proceed to the depot gate.* *The tram driver contacts OCC and request permission to proceed to the depot gate.*
Step 7	*Autonomous movements at the depot gate.* *After the request is approved, the tram autonomously proceeds to the depot gate at shunting speed and stops. The ATO system continuously monitors static and dynamic obstacles.*
Step 7.1	*The obstacle is detected, and the tram stops.*
Step 8	*The tram driver selects the route and contacts the traffic manager to request permission to enter the mainline. They must input the RTS before joining the mainline and always comply with OCC tram movement instructions. Before making any movements, they must ensure proper visibility and visually check the track for any obstacles.*
Step X	*If an unsuccessful communication confirmation or safety violation is detected at any point during the process, the operation will branch to the common outcome labelled as "X."* *Outcome "X" signifies that the operation cannot proceed successfully, and appropriate actions, such as reporting the issue to the OCC and halting the operation, will be taken.*

Postcondition	*The tram is deemed safe and operationally ready for departure if all pre-departure checks are successfully completed. OCC is ready to give a green line to leave for traffic area.*
Use case notes	*This Use Case has the following links with the operational rules (Annex 2):* - *OR.00.01 Communication with OCC* - *OR.00.05 Reporting defects and faults* - *OR.01.01 Driver check list before a trip* - *OR.02.01 After pre-departure check readiness* - *OR.02.06 Controlling motorized points within depots* - *OR.02.07 Track obstacles check before driving* - *OR.03.01 Recognising signals* - *OR.03.02 Recognising signs* - *OR.03.05 Tram cab key control modes* - *OR.03.12 Check proper visibility* - *OR.03.13 Acoustic signal before driving*

Table 3: Use case "Pre-departure tram check" description

4. UC.5.6.2.3.1: Autonomous shunting (from indoor to outdoor)

This use case sets an advanced application of Tram ATO technology within a depot environment, specifically focusing on autonomous operations. In various scenarios, the requirement arises to perform vehicle shunting activities within the depot, such as transitioning from indoor (e.g., a shelter) to outdoor locations or moving from the maintenance workshop to a sheltered area. This use case also integrates considerations of weather conditions as a pivotal parameter for adjusting the vehicle's driving characteristics and enhancing tram responsiveness to account for increased braking distances.

Use case field	Description
ID	UC.5.6.2.3.1
Use case name	*Autonomous shunting (from indoor to outdoor)*
Main actor	• *Autonomous tram* • *Tram remote driver-operator (remote operator)*
Other actors	• *Control centre operator or operations management room (at the depot) (OCC)* • *Depot personnel*
Use case summary	*This use case involves the autonomous shunting of a tram, allowing it to move between parking spaces without the presence of a driver. The tram transitions from a sheltered indoor area to an outdoor environment. Before initiating movement, the tram conducts a pre-movement self-check. The route is established by a remote operator, and the tram verifies its position and confirms movement with the OCC.*

	The OCC ensures that motorized points are correctly aligned, and the tram checks that the track is clear for movement. Once outside, it adapts its speed and driving style based on environmental conditions and encountered obstacles.	
Applicability	• *Geographical: Europe* • *Operational category: Urban*	
Main goal	*The main goal of this use case is to autonomously shunt a tram from an indoor parking space to an outdoor location while ensuring safety and adaptability to changing environmental conditions.*	
Preconditions	• *The tram is in a state ready for autonomous shunting.* • *Communication between the remote operator and the tram is established.*	
Termination outcome	**Successful outcomes**	• *The tram successfully completes the shunting process from indoor to outdoor.*
	Unsuccessful outcomes	• *The tram encounters obstacles or adverse environmental conditions that require intervention.* • *Communication between remote operator and the tram or with the OCC is lost.*
Condition affecting termination outcome	**Outcome 2**	*If the tram encounters obstacles or adverse environmental conditions, it must take appropriate actions as per the operational rules and instructions from the OCC.*

Use case scenario	**Step 1**	*Pre-Movement Self-Check*
		
		The remote operator initiates a self-check remotely to ensure the tram is in a suitable operational condition. Additionally, the following checks must be performed:
		• *Through perception system:*
		  ○ *Verify power is on and red light is illuminated*
		  ○ *Confirm that there is no crane obstructing the tram's path*
		  ○ *Check for any tags indicating that the tram cannot be moved*
		  ○ *Ensure no person is working on or near the tram*
		  ○ *Tram is not coupled to another tram*
		• *Conducted by depot personnel*
		  ○ *Verify the absence of scotches under the wheels*
		  ○ *Ensure that body catchers are raised*
		  ○ *Confirm that all panels are securely fastened.*

	Step 1.1	*If any failures are identified during this stage, the tram must transmit this information to both the remote operator and the OCC.*

	Additionally, if the Overhead Catenary System is off, a request to the OCC must be transmitted.
Step 2	*Route Setup* *After successful self-check, a remote operator sets up the route from A to B.*
Step 3	*Position Verification and OCC Confirmation* *The tram verifies its position and requests approval from the OCC. OCC must approve the request.*
Step 4	*Setting up motorized points* *The OCC adjusts motorized points according to the tram route.*
Step 5	*Visual check of the tracks* *The tram verifies that the track is clear for movement.*
Step 5.1	*If there is an obstacle on the track, the tram must evaluate how dangerous the object is (e.g., whether it is newspaper or a person) and then make a decision: proceed or follow the instructions (e.g., use chimes or stop and communicate to the OCC).*
Step 6	*Acceleration and Shunting Mode Activation* *The tram turns shunting mode and starts accelerating and approaches the shelter's gate. It chimes to indicate its intention to move through the gate.*
Step 7	*Scanning for Obstacles* *The tram scans its surroundings for obstacles and assesses safety.*
Step 8	*Outdoor Operation* *The tram continues moving outside, adjusting its speed, and driving style based on factors such as curves, junctions, time of day, weather conditions, and reflexes in the surroundings.*
Step 9	*Obstacle Recognition and Braking* *The tram encounters a fallen tree on the tracks. It recognises the obstacle and initiates braking.*

	Step 10	*Communication with OCC* *Information about the obstacle is sent to the OCC.*
	Step 11	*OCC instructions* *The OCC gives instructions to the tram to stop and wait for personnel to remove the tree.*
	Step 12	*After driving is restored, the tram proceeds to the final destination. The supervising systems that ensure tram safety are automatically deactivated after the tram comes to a halt.*
	Step 12.1	*If a tram deviates from the route and exits the autonomous-operation area, the system initiates braking to stop the tram. The remote operator is then notified of the issue, and OCC is contacted.*
Postcondition	*The tram successfully completes its autonomous shunting from indoor to outdoor.* *If an obstacle is encountered, the tram follows OCC instructions and stops, ensuring safety until the obstacle is cleared.*	
Use case notes	*This use case outlines the procedures and rules for autonomously shunting a tram, considering various environmental factors, and ensuring safety throughout the process.* *This Use Case has the following links with the operational rules (Annex 2):* - *OR.00.01 Communication with OCC* - *OR.00.02 End of communication with OCC* - *OR.00.05 Reporting defects and faults* - *OR.02.01 After pre-departure check readiness* - *OR.02.02 Tram movements in depots and workshops* - *OR.02.03 Driver check list before moving inside or outside the workshop* - *OR.02.04 Actions to do if power is off before entering or leaving the workshop* - *OR.02.05 How to enter/exit workshop after driver checklist* - *OR.02.06 Controlling motorized points within depots* - *OR.02.07 Track obstacles check before driving* - *OR.03.01 Recognising signals* - *OR.03.02 Recognising signs* - *OR.03.03 Speed principle* - *OR.03.05 Tram cab key control modes* - *OR.03.06 Factors affecting accelerating or braking capacity* - *OR.03.08 Driving technique on slippery track* - *OR.03.12 Check proper visibility* - *OR.03.13 Acoustic signal before driving*	

	- *OR.03.14 Detect obstacle (object in the or near track)*

Table 4: Use case "Autonomous shunting (from indoor to outdoor)" description

5. UC.5.6.2.2.1: Autonomous shunting of several vehicles simultaneously using V2X

General context

The primary focus of this use case is vehicle management, specifically the replacement of an out-of-service tram with an operational one. This requires the implementation of V2X communication, which serves as a comprehensive framework for exchanging information among multiple trams and the surrounding infrastructure. It is important to note that, for this use case, the assumption is made that the depot's infrastructure is advanced enough to support these operations.

Use case field	Description
ID	UC.5.6.2.2.1
Use case name	*Autonomous shunting of several vehicles simultaneously using V2X*
Main actor	• *Two autonomous trams* • *Tram remote driver-operator (remote operator)*
Other actors	• *OCC (Operations Control Centre)* • *Infrastructure*
Use case summary	*This use case encompasses the simultaneous autonomous shunting of multiple trams, a process designed to enhance operational efficiency, particularly in scenarios requiring tram substitutions, such as directing a malfunctioning tram to the maintenance workshop. To achieve this, V2X technology is used for precise coordination and control of the trams' movements.*
Applicability	• *Geographical: Europe* • *Operational category: Urban*
Main goal	*The primary objective of this use case is the simultaneous autonomous shunting of multiple trams, achieving efficiency and coordination through V2X communication. It's important to note that this use case does not rely on cameras for environmental analysis but instead leverages V2X communication to interact with infrastructure components and other vehicles, all operating within the V2X protocol. Additionally, the interconnected infrastructure facilitates automated management of signals and motorized points.*
Preconditions	• *The trams are in a state ready for autonomous shunting.* • *Communication between the trams and remote operator is established.*

Termination outcome	**Successful outcomes**	• *Two trams are successfully shunted simultaneously.* • *Communications between the trams, infrastructure and the remote operator are maintained.*
	Unsuccessful outcomes	• *Coordination issues among multiple trams result in conflicts or collisions.* • *Communication with OCC, remote operator or with infrastructure is lost.*
Condition affecting termination outcome	**Outcome 2**	*If coordination issues or conflicts arise among multiple trams, they must follow protocols to resolve the situation. The OCC must be notified.* *If the communication with any of the actors is disrupted, the systems must be relaunched and try to reconnect following the network's protocols.*
Use case scenario	**Step 1**	*Remote operator establishes V2X communication between the trams and with the infrastructure and verifies that communication works properly.*
	Step 1.1	*If connection fails to set up, the remote operator must repeat an attempt, following the network's manual. In case of unsuccessful attempts, the remote operator must contact the OCC for the instructions.*
	Step 2	*Route Planning and authorisation* *The remote operator set up the routes for the trams to shunt. The trams verify their positions and send confirmation to the remote operator. The remote operator contacts the OCC to confirm the shunting procedure. The OCC authorises the movement.*
	Step 2.1	*If the OCC doesn't respond, the remote operator must repeat an attempt, following the protocols.*
	Step 2.2	*In case of unsuccessful attempts, the shunting process must be terminated.*
	Step 3	*Pre-Movement Checks* *Both trams are required to perform pre-movement checks and communicate their readiness to the remote operator.*
	Step 3.1.	*In case of failures and other issues, remote operator must notify the OCC.*
	Step 4	*Shunting Initiation*

		Remote operator initiates autonomous shunting.
	Step 5	*Shunting and Coordination* *Trams autonomously shunt simultaneously, coordinating their movements. The trams also communicate with the infrastructure allowing the motorised points to adjust according to the trams' routes.*
	Step 6	*Communication with remote operator* *Trams maintain communication with the remote operator throughout the process to ensure control and safety.*
	Step 6.1	*In case of communication with the remote operator is disrupted or unavailable, the procedure must be immediately terminated, and the trams must halt.*
Postcondition	*Multiple trams are successfully shunted simultaneously using V2X communication.* *In the event of conflicts or collisions, trams follow protocols to ensure safety and resolve the situation.*	
Use case notes	*This use case outlines the procedures and potential unsuccessful scenarios for autonomously shunting multiple trams simultaneously, emphasising the importance of coordination and V2X communication.* *This Use Case has the following links with the operational rules (Annex 2):* • *OR.00.01 Communication with OCC* • *OR.00.02 End of communication with OCC* • *OR.02.02 Tram movements in depots and workshops* • *OR.02.03 Driver check list before moving inside or outside the workshop* • *OR.02.04 Actions to do if power is off before entering or leaving the workshop* • *OR.02.05 How to enter/exit workshop after driver checklist* • *OR.02.07 Track obstacles check before driving* • *OR.03.01 Recognising signals* • *OR.03.02 Recognising signs* • *OR.03.12 Check proper visibility* • *OR.03.13 Acoustic signal before driving* • *OR.03.14 Detect obstacle (object in the or near track)*	

Table 5: Use case "Autonomous shunting of several vehicles simultaneously using V2X" description

6. UC.5.6.10.3: Wheel profile examination

General Context

The use case represents a specific maintenance procedure: laser wheel profile examination, showing the benefits of remote driving to optimise the examination process. With higher level of autonomy, the use case can be transformed to autonomous operation.

Use case field	Description	
ID	UC. 5.6.10.3	
Use case name	*Wheel profile examination*	
Main actor	*Tram remote driver-operator (remote operator)*	
Other actors	*Control centre operator or operations management room (at the depot) (OCC)*	
Use case summary	*This use case involves the remote operator establishing a connection with a tram and following specific instructions for wheel profile examination. The remote operator initiates laser measurements and controls the tram to move at shunting speed until all the wheels pass through the laser. After the measurement, they complete specific protocols defined by the network operator.*	
Applicability	• *Geographical: Europe* • *Operational category: Urban*	
Main goal	*The main goal of this use case is to optimise the precise measurement of a tram's wheelbase using laser technology in remote driving regime.*	
Preconditions	• *The tram is in remote driving regime and ready for measurement.* • *Communication between the remote operator and the tram is established.*	
Termination outcome	**Successful outcomes**	*The laser measurement of wheels is completed accurately and without issues.*
	Unsuccessful outcomes	*The tram fails to follow the procedure.*
Condition affecting termination outcome	**Outcome 2**	• *The connection between the remote operator and the tram is disrupted.* • *Obstacles on the tracks prevent the procedure's continuation.*
Use case scenario	**Step 1**	*Connection Establishment*

		The remote operator establishes connection with the tram.
	Step 1.1	*Communication issues prevent connection. The remote operator must report the issue to the OCC.*
	Step 2	*Send the procedure request to* the OCC. *The remote operator sends the request for wheels measurement procedure to the OCC. The OCC confirms the request.*
	Step 2.1	*The communication with OCC fails or the request is rejected. The procedure is terminated.*
	Step 3	*Laser Measurement Initiation* *The remote operator initiates the control of the vehicle in order to reach laser measurement equipment.*
	Step 4	*Tram movements* *The remote operator controls the tram at the shunting speed until all the wheels are measured then proceeds to the defined parking spot according to the confirmed route.*
	Step X	*If at any moment of the procedure the obstacle appears on the tracks, the remote operator must terminate the procedure, otherwise, the advanced driving assistance system initiates emergency braking.*
Postcondition	*Successful execution of procedure. The tram is parked on the pre-defined parking spot.*	
Use case notes	*This use case describes the process of measuring a tram's wheels using laser technology and remote driving regime.* *This Use Case has the following links with the operational rules (Annex 2):* • *OR.00.01 Communication with OCC* • *OR.00.02 End of communication with OCC* • *OR.00.05 Reporting defects and faults* • *OR.02.07 Track obstacles check before driving* • *OR.03.13 Acoustic signal before driving* • *OR.03.14 Detect obstacle (object in the or near track)*	

Table 6: Use case "Wheel profile examination" description

3.2.2 Commercial areas

Based on the analysis of operational rules for commercial operational environment presented in Annex 3, the following use cases can be a basis for development of them in the follow up projects.

Functional use cases:

1. Self-test functions
    - More advanced self-test functions, e.g., clearing TCMS interface failures without driver involvement
2. Obstacle detection and speed adjustment:
    - Detection of moving objects on the tracks
    - Detection of moving objects along the trajectory that might lead to a collision
    - Decision-making regarding speed adjustments
3. Automated acoustic signals
    - Automated use of acoustic signals when needed
4. Real-Time Tram Positioning
    - Real-time tram positioning on a line
5. Control of Speed
    - Accelerating, decelerating and stopping
6. Signs, Signals, and Markings
    - Detection of signs, signals, and markings, including temporary ones and those out of order
    - Using a perception system to make decisions on speed adjustments in various weather conditions and times of the day
7. V2X Communication
    - Detection and anticipation of signals via V2X protocols
    - Detection and anticipation of the trajectory of other traffic users via V2X protocols
    - Decision-making on speed and acceleration/deceleration in response to V2X communication

Operational use cases to consider:

1. Crossings and Intersections
    - Driving over pedestrian crossings
    - Driving over crossroads using a perception system
    - Priority driving over a crossroad with V2X communication in place
2. Platform approach and stops
    - Tram approaching the platform and stopping at a stop marking.

- Automated turning of a vehicle at the terminus

3. Track control
   - Driving over switch points
   - Changing tram speed and acceleration/deceleration on straight and curved lines
   - Adjusting tram speed and acceleration/deceleration at specific times of the day and in specific weather conditions
   - Adjusting tram speed and acceleration/deceleration to maintain distance between tram vehicles
4. Tram coupling/decoupling
   - Coupling/decoupling of trams at specific tram stops
5. Infrastructure and vehicle maintenance
   - Automated check of infrastructure/vehicle performance/damage
   - Monitoring the condition of tram components and systems to predict maintenance needs and reduce downtime
   - Registration and reporting of deviations and the need for maintenance (e.g., for tracks, catenary, vehicle sub-systems)
6. Schedule adherence
   - Adjusting tram speed, acceleration/deceleration, and time spent at stops following a driving schedule
7. Passenger operations
   - Disembarking/embarking of passengers at platforms and terminus
8. Sub-system failures
   - Tram behaviour and procedures in case of vehicle sub-system failures identified by a tram self-test system:
     - Radio system failure
     - Braking failure
     - Safety loop failure
     - Vigilance device failure
9. Driver intervention
   - Behaviour of a tram and the procedure of taking control over automation by a driver.
10. Emergency response
    - Automatic initiation of emergency procedures, such as alerting the appropriate authorities or emergency services in case of a critical incident

These use cases cover a range of scenarios for the commercial operational environment of trams and can serve as a foundation for further development projects. Additional use cases can be identified and added as needed based on specific tram operators' requirements.

4 OPEN POINTS

Tram behaviour in emergency situations within depot operations are not considered in this deliverable. However, the deployment of automation and autonomy in a depot to its full potential necessitates addressing these scenarios. Thus, it is advisable in future to focus on specific use cases that address these aspects of tram operations within non-commercial areas.

Another unresolved issue concerns to the harmonisation of technologies and ATO setup in non-commercial areas. To accomplish technological consistency for autonomous tram operations at an industrial scale, standardisation plays a pivotal role. Standardisation ensures the seamless compatibility of different systems and components, facilitating interoperability and efficient operations. To achieve market acceptance, fostering mutual understanding among industry stakeholders and other involved parties, including operators and organising authorities, is vital.

The development of autonomous tram operations within commercial areas presents a challenge due to the presence of other road users in mixed traffic environments. At this stage of autonomous system development, the primary focus should be on enhancing the advanced driving assistance system, with a specific emphasis on defining GoA2+. The scope of this development should be set out within the framework of the FP2 program, and the use cases presented in Section 3.2.2 can be a basis for this work.

According to GoA specification applied for metro systems, the difference between GoA2 and GoA3 is that in GoA2, traction and braking are performed automatically by ATO, while the driver is still present to supervise the doors operation and operations when disruptions occur. In contrast, in GoA3, there is no driver anymore, but onboard staff remains present. Starting and stopping are automated, but a train attendant operates the doors and drives the train in case of emergencies. In this system, trains run automatically from station to station, but a staff member is always in the train, with responsibility for handling emergency situations. In a GoA3 system, the train cannot operate safely without the staff member on board.

However, the operational context of tram systems is more complex than that of metro systems. Trams operate within open environments with mixed traffic, involving diverse stakeholders such as cars, other public transportation modes, pedestrians, and passengers. This complexity necessitates not only automation but also autonomy, adding an extra layer of safety and security and altering the dynamics between tram operators and other road users in emergencies. Addressing issues like determining responsibility in the unfortunate event of a fatal accident involving an autonomous tram becomes a challenge. This paradigm shift in operational approach bears implications for legal and regulatory considerations. It is essential to acknowledge that the deployment of autonomous trams on public roads, although technologically feasible, is not an immediate prospect without in-depth analysis. In this regard, one of the recommendations of the UITP R2DATO working group was to establish a collaboration with the road automation industry. The challenges they face and the technologies they use are similar to those in the LRT sector.

While this work does not encompass the exhaustive examination of legal, regulatory, and ethical aspects, it is recommended that further efforts be made to explore the current regulatory framework in the European Union and address ethical questions to provide recommendations for enabling autonomous tram operations. This initiative might involve collaboration with road operators and the automobile industry to comprehensively address the complexities of autonomous tram operation.

The introduction of automation in depots not only transforms daily operations but also necessitates a reconsideration of depot organisation and infrastructure. The UITP R2DATO working group has raised several crucial questions for further discussion, including:

- Defining levels of automation and autonomy: one key question revolves around the classification of different levels of automation and autonomy within depots. These levels can range from assisted driving to remote control and driving to full autonomous operations. Determining the criteria for each level is essential for establishing a framework for automation implementation.
- Impact on depot design: the introduction of automation at various levels has a significant impact on the design and layout of depots. It is essential to understand how each level of automation influences the physical infrastructure and operational procedures within the depot.
- Standardisation and harmonisation: another vital consideration is what aspects of automation can be standardised or harmonised across depots. This includes areas such as V2X (Vehicle-to-Everything) communications, where standardisation can enhance interoperability and efficiency.
- Cybersecurity: ensuring the safety and security of automated systems is paramount. How can depot automation systems be safeguarded against cybersecurity threats, and what measures should be in place to guarantee their safe operation?
- Motivating operators to adopt new technologies: implementing new technologies in depot management requires the buy-in of operators. What strategies can be employed to motivate operators to embrace and transition to these advanced automation technologies in depot operations?

CONCLUSIONS AND RECOMMENDATIONS

Tramway operational environment differs from mainline and therefore this segment has specific use cases and user requirements. This distinction necessitates a focus on specific use cases and user requirements, particularly within the commercial operating context.

Within task 5.6, we undertook the collection, analysis, and harmonisation of operational rules for both non-commercial areas (such as depots and shelters) and commercial areas. These efforts have resulted in the establishment of a framework that aligns with WP6 (allocation of functions to the use cases) and supports demonstrations in WP40, 41, and 42. Our approach was collaborative, benefiting from the valuable contributions of working group members and experts in tram automation. We also drew insights from related projects like TAURO and ELASTIC.

This approach showed the importance of involving end users in the development process early on. Understanding the unique operational rules of tramway systems and their specific user requirements is a prerequisite for the successful adoption of automation technologies.

During our task and its progression, we recognised the following limitations:

1. The priority was given to use cases in non-commercial operational areas that are not accessible to the general public and other road users. This choice aligns with the primary focus of R2DATO tram demonstrations.

2. Use cases were selected based on feasibility and benefits, prioritising those with significant advantages and easier implementation. In contrast, use cases with limited implementation potential or those tied to emergency situations were postponed. This choice was guided by ethical and legislative factors, as emergency scenarios typically involve human decision-making, making deployment unfeasible at this stage of technological development. The analysis of priority/non priority use cases, as well as what was included in the use cases can be found in the last two columns of Annex 4.

The process of identifying operational rules has proven to be a good exercise, not only in terms of generating potential use cases but also in establishing essential limitations and a structured framework for the deployment of ATO. By outlining operational rules, we lay the foundation for a smooth transition to ATO while respecting the existing operational context.

Among the identified use cases, several have been selected as top priorities for the operators:

- Remote driving in a depot;
- Remote washing;
- Pre-departure tram check;
- Autonomous shunting;
- Autonomous shunting of several vehicles simultaneously using V2X.

In terms of recommendations, future projects can explore specific emergency and "out of order" use cases for non-commercial areas. For commercial tram operational environments, we advocate the development of use cases representing advanced ADAS with elements of GoA2+. At the same time, members of the UITP R2DATO group expressed concerns about the usage of the GoA methodology applicable to metro and other closed systems. A new methodology, closed to the road automation industry, should be developed, and the use cases should encompass enhanced self-diagnostic capabilities, improved obstacle detection, autonomous track control, V2X communication, and optimized emergency responses.

Additionally, our investigation has brought insights regarding technological harmonisation and standardisation at an industrial level. This will support the integration of tram automation systems and ensure interoperability. Such measures will be instrumental in guaranteeing market acceptance by the operators. Facilitating a dialogue between manufacturers, operators, and organising authorities can support this effort, including the development of future tender specifications and understanding business models (e.g., data ownership, software updates, etc.), as well as transition costs.

Lastly, we underline the importance of addressing legal, regulatory, and ethical issues that concern the market deployment of ATO systems for trams. Resolving these issues is essential for the widespread adoption of tram automation technologies.

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ANNEXES

ANNEX 1: USE CASE TEMPLATE

Use case field	Description	
ID	UC.5.*[# of task].[# of UC]* (COL. A. in Index)	
Use case name	*[Name of the UC.]* (COL. G in Index)	
Main actor	*Actor that initiates the UC*	
Other actors	*List of all actors that play any role during UC scenario in any event of the UC.*	
Use case summary	*[General summary]* (COL. H in Index)	
Applicability	*Provide a description to which topics the use case is applicable. Provide information on the below fields.* (COL. I, J and K in Index) • *Geographical (national level, which countries? / European level)* • *System level (for which system(s) is the UC applicable?)* • *Operational category: passenger, freight, urban, regional, mainline and inspection vehicles*	
Main goal	*Description of the UC main goal – what operational scenario* *(concept) is provided.* *Example: "ensure train end of operation procedure including* *inspection everything is performed properly".*	
Preconditions	*[Describe the minimum previous conditions to carry out the UC.]*	
Termination outcome	**Successful outcomes**	• *[Outcome 1: Successful outcome of the UC.]*
	Unsuccessful outcomes	• *[Outcome 2: Unsuccessful outcome 1 of the UC.]* • *[Outcome 3: Unsuccessful outcome 2 of the UC.]* • *[Outcome 4: Unsuccessful outcome 3 of the UC.]*
Condition affecting termination outcome	**Outcome 2**	*[Explanation and post-conditions for unsuccessful outcomes.]*
Use case scenario	**Step 1**	*[Step 1 to be followed to achieve the UC.]*
	Step 1.1	*[Branch from Step 1 to unsuccessful outcome X.]*
	Step 1.1.1	*[Branch from Step 1 to unsuccessful outcome X.]*

	Step 2	*[Step 2 to be followed to achieve the UC.]*
	Step 3	*[Step 3 to be followed to achieve the UC.]*
	Step 3.1	*[Branch from Step 3 to unsuccessful outcome X.]*
	Step 3.1.1	*[Branch from Step 3 to unsuccessful outcome X.]*
	…	*…*
	Step n	*[Step n to be followed to achieve the UC.]*
	Step 6	*[Use Case successfully ends.]*
Postcondition	*Defines all conditions that have to be fulfilled when the UC is successfully completed.* *Example: "specific system is switched off, some actor is in specific operational status".*	
Use case notes	*[Notes and comments.]*	

Table X: Use case "Use case name" description

ANNEX 2: OPERATIONAL RULES FOR NON-COMMERCIAL AREAS AND DEPOTS

Number	Who added the UC	Activity Group	Activity name	Activity Summary	Actors
OR.00.01	R2DATO	00_General	Communication with OCC	When communicating with OCC, both sides must confirm that they have received the information in bi-directional communication. Moreover, OCC must identify which tram contacted them and where it is located. If the tram does not receive any confirmation from OCC, it must repeat the attempt as many times as specified by the network operator.	* OCC * Driver
OR.00.02	R2DATO	00_General	End of communication with OCC	Communications are always concluded by OCC	* OCC
OR.00.03	R2DATO	00_General	Notification of changes in signals and signs	OCC and driving staff must be notified of any changes in the use, location or modification of a signalling device, permanent speed sign or similar.	* OCC * Driver
OR.00.04	R2DATO	00_General	Central Control Room Evacuation	If the OCC is evacuated, all drivers must be informed and communications minimised, following the specific procedures adopted by the network.	* OCC * Driver
OR.00.05	R2DATO	01_Before Start	Reporting defects and faults	Any defects or faults must be reported to the OCC as soon as possible.	* OCC * Driver * Other personnel
OR.01.01	R2DATO	01_Before Start	Driver check list before a trip	Every network operator has a driver checklist that must be went through by a driver before each trip. It may contain the following items, among others: external lights, panels (are secured), body catchers (raised), under wheels (no scotches), targets/tags in any cab, safety brake (red mushroom is in the raised position). While the tram is being prepared by turning drivers key to "P", need to check all safety equipment and seals being present. After the tram is ready, the cab must be activated by turning the driver key to NM, the following might be included in the check list: chimes & horns, all lights, wipers & washer, PA, doors open and close, safety break, track brake, console indicator lamps work, traction, functionality of mirror cameras, saloon (visual check, i.e., i.e. floor is clean, dry and clear of any obstructions, emergency handle covers in place, overhead panels are secure, and inspect widows for defects, seal on the first aid kit box, seal on fire extinguisher, if switch iron for manual operation of the switches is on place, inside of the vehicle for graffiti and damages), outside of the vehicle for graffiti and damages, pantograph raised, control of alarms on TCMS-HMI monitors or alarm lamps on driver desk.	* Driver

OR.01.02	R2DATO	01_Before Start	Vigilance device (Deadman function) activation/deactivation	Vigilance devices ensure the safety of the trams. They work differently in different networks, but the basic idea is that they will sound an alarm and activate emergency braking if the driver does not follow the instructions. The vigilance device must be activated before starting the tram and deactivated after stopping the tram. The vigilance device must not be bypassed or tampered with. The vigilance device must be tested before each shift and reported if faulty.	* Driver
OR.01.03	R2DATO	01_Before Start	Initialising the AVLS	During the departure pre-check AVLS must be initialized by entering the driver's I.D. and service number	* AVLS
OR.02.01	R2DATO	02_Start and Control	After pre-departure check readiness	The driver/tram must complete the pre-departure check and ensure it is successful before leaving storage. Then, they must contact OCC and request permission to proceed to the depot gate. At the depot gate, they must follow the instructions from the network operator (e.g., select the route or stop on the loop) and contact OCC again to request permission to enter main line. They must input RTS before joining the main line and always comply with OCC tram movement instructions. Check proper visibility before any movements and track for any obstacles for driving (visual).	* OCC * Driver
OR.02.02	R2DATO	02_Start and Control	Tram movements in depots and workshops	The OCC must authorize all tram movement requests in the depot/workshop. Then, the trams must move at the maximum speed that the network operator specifies.	* OCC * Driver
OR.02.03	R2DATO	02_Start and Control	Driver check list before moving inside or outside the workshop	If requested to move a tram inside or outside the workshop always check the following: power is on, red light illuminated, crane is not in the way, no tags indicating it cannot be moved, no person is working on or near the tram, tram is not coupled to another tram, no scotches under wheels, body catchers are raised, all panels are secured.	* Driver
OR.02.04	R2DATO	02_Start and Control	Actions to do if power is off before entering or leaving the workshop	The tram must stop and contact OCC if the light is green (Overhead Catenary System is off) or blank before entering or exiting.	* OCC * Driver
OR.02.05	R2DATO	02_Start and Control	How to enter/exit workshop after driver checklist	When entering or exiting the workshops (unless instructed otherwise), stop before the door, chime, and move in (SM) shunt mode if safe, and look around. Always chime for any depot movement, especially in low visibility areas such as sanding shed, wash, depot storage lanes, workshop doors etc. Use the horn if chimes are not working.	* OCC * Driver
OR.02.06	R2DATO	02_Start and Control	Controlling motorized points within depots	Motorized points within the depots are normally controlled by OCC.	* OCC
OR.03.01	R2DATO	03_Driving	Recognising signals	The driver must recognise the following types of signals: - movement signals: e.g., stop (+unless too close to stop safely), proceed if safe to do so; - signals indicating a tram proceed authorisation: e.g., proceed left/right if safe to do so; - signals indicating fault/failure: e.g., STOP blank/no signal and single dot --> contact OCC for further instructions; - indicator lamp to acknowledge receipt of the request; - point position indicators: point set to the left, point position is not detected, point is set to the right; - shunting signals (e.g., red/light signals in depots); - track number signal (when entering parking area)	* Driver

OR.03.02	R2DATO	03_Driving	Recognising signs	The driver must recognise the following types of signs: - speed sign; - stop sign (+ STOP and if safe to do so proceed with caution)m - yield sign (yield right of way to another light rail vehicle or to traffic on a road ahead); - other instructions signs, defined by the operator; - instruction signs: turning point; - coasting zones signs (e.g., SI locations); - signs forbidding any trams on the section	* Driver
OR.03.03	R2DATO	03_Driving	Speed principle	The speed indicated is the design speed; not a target speed, trams are driven under the Line-of-Sight principle, and speeds must be adjusted according to the environment or adverse weather conditions.	N/A
OR.03.04	R2DATO	03_Driving	Communicating tram signal number at junctions	Each tram signal pole at a junction has a number. The driver must tell this number to the OCC when communicating with them.	* OCC * Driver
OR.03.05	R2DATO	03_Driving	Tram cab key control modes	There are several driver key control modes: - Driver key on NM; Normal mode. Used for general driving. - Driver key on P; Used when performing a tram re-prep - Driver key on N; Neutral mode. The cab is not active. - Driver key on SM; Shunt mode. Used in the depot for running trams through the wash, in/out of the workshops, and during the procedure to couple trams for tow and push. In SM the speed is automatically limited to the one defined by the network operator. - Driver key on NM and push reverse PBLI (Push-Button Latching Type Illuminated). Reverse mode speed is automatically limited to the one defined by the network operator. The reverse mode is forbidden (except for tow/push and then only where a second driver is positioned at the rear of the tram)	N/A
OR.03.06	R2DATO	03_Driving	Factors affecting accelerating or braking capacity	Drivers must be careful of conditions that can reduce braking capacity, such as leaves, dew, rain, mist, fog, flooding, snow, road vehicles, etc. Braking distances can be 50% longer in wet conditions, especially on downhill slopes, near stops, and in the city.	* Driver

OR.03.07	R2DATO	03_Driving	Speed limits	The network operator sets up the different speed limits, e.g., maximum speed allowed on any part of the network, maximum permitted speed of an in service tram approaching a platform, maximum permitted speed of an out of service tram passing through a platform, maximum permitted speed of all trams passing through any non-operational platforms, approaching spring points speed, when pulling/pushing coupled trams on the line, when pulling/pushing coupled trams in the depot, when moving within the depot area, during shunting movement, etc. The following speed limits apply where no lower speed is dictated by a permanent or temporary speed sign, safety notices, and OCC emergency instruction or by other circumstances.	N/A
OR.03.08	R2DATO	03_Driving	Driving technique on slippery track	Some techniques to be used on slippery track: - Adjust acceleration to avoid slippage on departure (i.e. do not apply full traction) - Avoid rapid movement of the Master Controller from traction to braking and vice versa - Reduce speed, especially on street, taking into account increased stopping distances - Adjust the speed and start to brake well in advance of stops and junctions - Reduce entry speed at stops, use chimes if necessary	* Driver
OR.03.09	R2DATO	03_Driving	Turning trams in depots	Before moving, check that the route is clear and approved by OCC. Do not stable or reverse a tram over points unless it is an emergency or specific instructions. Stop at the proper and assigned position (for one tram or coupled).	* OCC * Driver
OR.03.10	R2DATO	03_Driving	Washing procedure	Before entering the wash, all windows and hatches must be closed. (SM) shunt mode need to be selected which define speed limitation. Then OCC must approve request of program activation. On receiving a green light, proceed until the whole tram has cleared the wash. When exiting the wash, use the chimes as the visibility is restricted. If the tram is stopped during the process, the wash will stop automatically and will not start again until reset by OCC.	* OCC * Driver
OR.03.11	R2DATO	03_Driving	Wrong directional moves	Moving in the wrong direction is only permitted when it is authorised by the OCC and when a clear understanding has been reached and confirmed between the driver and OCC. The procedure may include these actions: switching to the leading cab, checking the points before moving, moving through crossing roads in the wrong direction with permission from OCC or Gardai. Before moving, the section must be made sure that there are no trams in it by the OCC.	* OCC * Driver
OR.03.12	R2DATO	03_Driving	Check proper visibility	Before any movements, proper visibility must be ensured. The following items must be checked: window cleanliness, defrost function, camera views, etc.	* Driver
OR.02.07	R2DATO	02_Start and Control	Track obstacles check before driving	Before any movements, the track must be checked for clearance before driving. No object must be allowed to cross the yellow lines that mark the driving profile.	* Driver
OR.03.13	R2DATO	03_Driving	Acoustic signal before driving	The acoustic signal must be used before the tram is moved.	* Driver
OR.03.14	R2DATO	03_Driving	Detect obstacle (object in the or near track)	When moving, the driver must watch for any obstacles on or near the track that could make the tram slow down or stop.	* Driver

OR.03.15	R2DATO	03_Driving	Right of way at non signalled areas	At non signalled areas, the right of way must be given to the vehicle on the right.	* Driver
OR.03.16	R2DATO	03_Driving	Event of unintended train separation	In the event of unintended train separation, at least the vehicles not manned by a driver shall be braked automatically; the train separation shall be recognisable for the driver or the OCC.	* OCC * Driver * Tram
OR.03.17	R2DATO	03_Driving	Braking in the event of derailment	If driverless train operation is performed, the vehicle shall be able to brake to a halt immediately and automatically in the event of derailment.	* Tram
OR.03.18	R2DATO	03_Driving	Design of traction and brake control	The traction and brake control shall be so designed that brake commands have precedence over traction commands; the tractive efforts and the brake forces are altered at minimum jerks; the execution of braking commands is monitored if driverless train operation is performed.	N/A
OR.03.19	R2DATO	03_Driving	Person's detection in danger zone > 5m	When trains are in motion, persons entering the danger zone further than 5m in front of the train nose or behind the end of the train (coupling) must be detected.	* Driver
OR.03.20	R2DATO	03_Driving	Person's detection in danger zone < 5m	Persons entering the danger zone closer than 5m in front of the train need only be detected by the cut-off device which triggers braking on contact with an obstacle.	* Driver
OR.03.21	R2DATO	03_Driving	Stopped train and persons' recognition	When trains are stopped, persons entering the danger area more than 50 cm in front of the head of the train or more than 50 cm behind the end of the train (coupling) must be recognized.	* Driver
OR.04.01	R2DATO	04_After Parking	Equipment for doors	Passenger vehicles shall be provided with equipment that: indicate to the driver that the doors are closed, allow opening of the doors on one side only if the vehicle has doors on both sides; ensure that the train can only start when all the doors are detected closed if driverless train operation is performed.	N/A

ANNEX 3: OPERATIONAL RULES FOR COMMERCIAL AREAS

Number	Activity Group	Activity name	Activity Summary	Applicability: systems	Actors	Expected outcome
OR.00.06	00_General	Communication in case of emergency	Where use of the radio or cab phone is not possible, communications must take place via the Emergency Help Point.	Communication and control	* Driver * OCC * Emergency Help Point	Information is communicated via the Emergency Help Point.
OR.00.07	00_General	Use of sand	Where possible, tram sanding is automatic and synchronised by the tram system. Manual sanding over points is prohibited.	Sanding system	* Sanding tram system * Tram driver * Sandbox * Sand nozzle * Sand	The grip of the tram wheels is improved.
OR.00.08	00_General	Emergency Speed restrictions	In the event of an Emergency Speed Restriction (ESR), OCC informs all drivers of the applicable speed and location of the ESR.	Communication and control	* Tram drivers * OCC	All the drivers are informed about emergency speed restriction.
OR.00.09	00_General	Exceptional single line running	Exceptional single line running can be implemented by the OCC where a section of track is used as a single line for trams operating in both directions.	Signalling	* OCC * Trams * The section of tracks * Tram drivers	Single line running is implemented without any accidents.
OR.00.10	00_General	System failure notification	All staff is required to report to OCC anything that disrupts, deviates from, or affects the normal service, staff or passenger safety. A driver must immediately inform OCC if, as a result of a disruption, he/she has to leave the driver's cab or if the tram is expected to be delayed by more than X (to be defined by the operator) minutes. Before leaving the cab, a driver must receive authorisation from the OCC to do so. The passengers must be informed via PA announcements. Any accident, fire, the appearance of smoke, personal injury, or an installation failure that could threaten tramway safety must be immediately reported.	Communication and control	* Tram Drivers * Other staff: controllers, maintenance workers, security personnel, etc. * OCC * The passengers * PA system	All stakeholders are notified about a system failure as necessary
OR.00.11	00_General	Infrastructure damage	In case of infrastructure damage, the following procedure might take place: 1) The tram must be stopped as soon as possible when it is safe to do so; 2) The hazard lights must be put on 3) OCC must be called and informed the exact location and direction of travel 4) The damage must be clearly stated: e.g., broken or defective rails, overhead contact system pole damaged or sagging, bridge collision 5) Need to be assessed if both lines are affected and if emergency de-energisation is required 6) OCC must contact maintenance and advise the driver of the procedure to follow	Communication and control	* Tram driver * OCC * Maintenance staff * Hazard lights * Communication system * Track infrastructure	Information about infrastructure failure communicated in a timely manner
OR.00.12	00_General	Failure of the radio system	In the event of an entire radio system failure the driver must use the Emergency Help Point as a backup at the stops. If unable to contact OCC for emergency purpose only a driver may use other communication means, such as a mobile phone or public phone only when the tram is at standstill and if safe to do so.	Communication and control	* Tram driver * OCC * EHP * Mobile phone/public phone * Radio system	The driver communicated about emergency and failure of the radio system.

OR.00.13	00_General	Tram failure and sealed switches	Sealed switches cannot be broken without prior authorisation from OCC. Broken seals must be reported to the OCC immediately. The systems with the sealed switches may be: brakes isolation, pump power supply, dead man's device isolation, door monitoring isolation, loops power supply control.	Communication and control	* Tram drivers * OCC * Sealed switches * Seals * Loop power supply	Broken seals didn't lead to an accident.
OR.00.14	00_General	Brake failure indicated on TCMS	OCC to be contacted and advised of brake status as shown on the TCMS. The OCC instructions to be followed for the sequence of actions. Attempt to De-prep & Re-prep the tram to clear the fault- the tram must perform a self-analysis test. If the brake failure is still present, authorisation from OCC to be sought to start a brake isolation procedure. The passengers must be detramed then brake isolation must be performed. Then on TCMS the brake status and bogie isolated symbol must be shown.	Braking	* Tram drivers * OCC * The passengers * TCMC * The brake system	The instructions are followed.
OR.00.15	00_General	Safety Loop failure	The safety loop can be isolated by breaking the seal only under OCC authorisation. After the OCC authorisation, all passengers must be detramed and safety loop isolation procedure must be started. Then the tram must proceed to a depot.	Safety	* Tram driver * OCC * Passengers * Safety loop * Depot	A tram safely returned to the depot.
OR.00.16	00_General	Vigilance Device Failure	Driving with the vigilance device seal broken unaccompanied is prohibited (unless for a short move in the event of an emergency such as threat to life, or under specific instruction). The vigilance device can only be isolated by breaking the seal and only under OCC authorisation. Before breaking the seal, the passengers must be detramed.	Safety	*The Tram driver * OCC * The passengers * The vigilance device * The second person (staff) * Safety brake	A tram safely returned to the depot.
OR.00.17	00_General	Traction Brake Control Unit (TBCU) failure	In case of TBCU failure, instructions will be provided by the OCC on how to deal with the failure. First the issue must be reported to the OCC, then the tram must continue to the platform (not in all cases) and acknowledge the TBCU fault message on TCMS. Trams must perform an automatic reset for TBCU failure then a driver must confirm to the OCC if the failure has cleared.	TCMS	* Tram driver * OCC *TCMS	After automatic reset for TBCU failure, the fault is cleared OR the fault is confirmed but the tram is successfully parked.
OR.00.18	00_General	Prioritisation of voice communication between passengers and an operation centre	If driverless train operation is performed, the fitted communications installations shall be able to prioritise voice communication between passengers and an operation centre.	Communication and control	* Passengers * OCC * Driverless tram	Voice communication between passengers and OCC is prioritised.
OR.00.19	00_General	Communication in tunnels	In tunnels there shall be communications installations that enable fast, reliable two-way communication between the police, the fire brigade, the rescue service, their centres of operation and the OCC of the company.	Communication and control	* Police * Fire brigade * Rescue service * OCC	The actors coordinated their actions and responded to any emergency in timely and efficient way.
OR.00.20	00_General	Equipment at stops to ensure that passengers are not endangered	If driverless train operation is performed, special equipment shall be provided at stops to ensure that persons are not endangered by moving trains.	Safety	* Driverless tram * Passengers * OCC * Special equipment ensuring safety at stops (to be defined)	The driverless tram operate smoothly and efficiently without endangering the passengers or causing any accidents or delays.
OR.00.21	00_General	Emergency intercom between passengers and the driver	Each passenger vehicle of a train without operational staff shall have an emergency intercom between passengers and the driver, which shall always be available. If driverless train operation is performed, each passenger vehicle shall have an intercom between passengers and the OCC.	Safety	* Passengers * Tram driver or Driverless tram * OCC * Emergency intercom	the passengers report any issue or request any assistance to the driver or the OCC through the emergency intercom, and the driver or the

						OCC can respond accordingly and take appropriate actions.
OR.00.22	00_General	Emergency break if passengers are on tracks at platform areas	The track area accessible from the platform is equipped with automatic devices that stop trains immediately if persons are present on the track.	Train protection	* Tram * Passengers * Track area * Automatic devices	
OR.01.04	01_Before Start	Tram prep: a driver to sign vehicle logbook	The driver must check and sign the Vehicle Log Book (or its analogue, depending on an operator) in both cabs to confirm that the driver pre-departure check has been performed, and to ensure that the Vehicle Maintenance Contractor (VMC) (in case, there is any) pre-service check has been completed and is valid. The VMC pre-service check is valid for X hours (to be defined by an operator)from the time it was performed.	Vehicle status reporting	* Tram Driver * Vehicle Log Book * Vehicle Maintenance contractor	The driver verified that the vehicle has been checked and ready for service.
OR.01.05	01_Before Start	Door operation: closure	Cameras (and mirrors if available) to confirm doors are clear of passengers/obstruction must be used. The chimes are used, and a PA announcement is made in case of crowding. The door must be closed. The side selection must be deselected only after the doors are closed otherwise the obstacle detection is not operative (passengers may be trapped and injured). A tram may only depart if it has been visually observed or technically proved that all its doors are closed.	Door control	* Tram driver * Passengers * Doors * Cameras * Mirrors * Chimes * PA system * Authorisation and side selection buttons	Driver ensure that the doors are clear of any obstruction before closing them, and that the passengers can board and alight the vehicle smoothly and comfortably.
OR.01.06	01_Before Start	Forced door closure	In the event that the forced door closure needs to be used, there is no obstacle detection which may injure passengers. Announcement to request passengers to stay clear of the doors must be made, the camera/mirrors that the doors are clear must be checked.	Door control	* Tram driver * PA system * Force door button * camera/mirrors	The driver closes the door safely and securely in force door mode.
OR.01.07	01_Before Start	Passenger Door Operations with Technical Faults	All doors on the affected side must be opened if safe to do so and an attempt to close must be made. In the event of crowding , a PA announcement should be made asking passengers to stand clear. OCC authorisation and extreme caution is required if the tram is not at a platform or if the affected door is trackside. If the fault does not clear, a manual reset is required. If the fault/failure does not clear on the TCMS or the door did not close automatically, the door has to be locked Out of service. When a door is manually locked out, but is still seen as open on the TCMS, the traction is inhibited, in this case the doors controls has to be by-passed.	Door control	* Tram driver * Passengers * Doors * TCMC * OCC * Emergency handle * Tram door key * Door Out of Order sticker * Door Isolation seal and switch	Driver can restore the normal operation of the door or isolate it from the door control system, and that the passengers can alight and board the vehicle safely and comfortably.
OR.02.08	02_Start and Control	Start a journey from the depot or terminus	This operational rule describes the sequence of actions the driver must do before a tram departs from the depot or terminus. 1) the departure time is according to the timetable or as instructed by OCC, and destination banners are correct, 2) the doors are clear before activating closure 3) If necessary in case of large crowds or if the driver does not have a clear view of the length of the tram, the driver must alert passengers via a PA announcement that the doors are closing. 4) When the doors have been closed, proceed if safe to do so 5) Enter a Ready To Start command prior to departure from each stop 6) Trams have to be driven according to the timetable, or as instructed by OCC	Operation and management	* Tram driver * Passengers * OCC	Tram departs from the depot or terminus on time and safely, and that the passengers are informed and comfortable.
OR.02.09	02_Start and Control	Unauthorised or wrong route selection	Procedure to apply: 1) Always stop, call OCC and wait for the instructions. 2) Stop and put the hazard lights on	Communication and control	* Tram driver * OCC	The tram recover from an unauthorised or wrong route selection safely and without

			3) Call OCC and inform them of the exact tram location, direction of travel, if platform is free where relevant 4) OCC will define the recovery procedure to implement(e.g., continue, perform a wrong directional movement by changing cab, wait for support)			causing any disruption or collision, and the driver and the OCC operator work together to resolve the situation.
OR.03.22	03_Driving	Observation of other trams and infrastructure	The driver should pay attention to other trams and immediately communicate any irregularities observed to OCC. The driver should report all infrastructure and tram damages or unusual behaviour to the OCC.	Safety	* Driver * OCC	All irregularities are communicated.
OR.03.23	03_Driving	Out of service trams returning/ stabling in the depot	These operational rules describe the actions a driver must perform when a tram is coming out of service: 1) Change the external banner to show Out of Service and switch off saloon lights 2) Adjust speed while passing by the platforms 3) Tram must be sanded and washed if instructed by OCC when returning to the depot for the night. 4) OCC will define the depot storage lane number when stabling in the depot, whether it's after a move or when coming out of service.	Operation and management	* Driver * OCC	Out of service trams are safely and efficiently returned and stored in the depot.
OR.03.24	03_Driving	Door when travelling	Travelling with side selection button selected is forbidden. Green door inhibition button must always remain selected while in passenger service.	Operation and management	Driver	N/A
OR.03.25	03_Driving	Driving when track works are happening	Tram must always reduce speed and use chimes and horn if required to be sure that the workers are aware of the approaching tram, and they are in a safe position. In the case of stop signs located on the track, stop and call the OCC.	Operation and management	* Driver * OCC * Track workers	Safe driving
OR.03.26	03_Driving	Tramway signalling failure	If the tram signals are blank or display a single dot, this will indicate a failure. In these instances, drivers must stop, contact OCC, and not move the tram until further instructions are issued by OCC. If a tram encounter a tramway signal in failure mode or permanent stop, not already communicated by the OCC, the following actions must be performed the tram must be stopped and the OCC must be contacted. The location must be confirmed.	Operation and management	* Driver * OCC	Safe driving
OR.03.27	03_Driving	Signal passed at stop without authorisation	If a signal is passed at stop, the driver must: 1) Stop as soon as possible when it is safe to do so 2) Put the hazard lights on 3) Contact OCC, and confirm: service number, staff I.D. number, the exact location, junction number and direction of travel where the Signal was passed at stop. 4) The incident must be recorded 5) OCC will issue further instructions	Operation and management	* Driver * OCC	Safe driving
OR.03.28	03_Driving	Road vehicles or objects blocking the track	The tram must approach the area with extreme caution at a reduced speed, sound the warning bell or horn If required, slow down and stop before the obstruction, put the hazard lights on and call OCC to inform the exact location and direction of travel. Report whether the object can be removed safely by the Driver, if it is not possible, OCC will contact the relevant staff to remove the object as soon as possible.	Operation and management	* Driver * OCC * road vehicles and other objectives	Safe driving

OR.03.29	03_Driving	Overcrowding on trams	Overcrowding to be communicated to the OCC. Driving must be smooth and the speed adapted to the conditions, use of slow take up of traction and soft controlled braking is preferred. Also could be done: 1) Internal PA advising the passengers of the next tram arrival 2) Before starting the door closure sequence, the PA to request passengers to "stand clear of the doors, doors are about to close" to be used 3) Provide sufficient time at tram stops to ensure that passengers wishing to alight have sufficient time to do so	Operation and management	* Driver * OCC * Pas * Passengers	Safe driving
OR.03.30	03_Driving	Left Luggage/Lost Property	In case of left luggage of lost property, the OCC must be informed. A driver must follow OCC instructions.	Operation and management	* Driver * OCC	Safe driving
OR.03.31	03_Driving	Tram is due to be out of service	When a tram is due to be out of service, an announcement must be made that this is the last stop, and all passengers must alight the tram. The driver must check and ensure that all passengers have exited the tram before closing the doors, and report to OCC if any passengers refusing to leave the tram and await OCC instructions.	Operation and management	* Driver * OCC * Passengers	N/A
OR.03.32	03_Driving	Disturbance on board a tram	A driver must call OCC and inform of the location, the nature of disturbance, and number involved, the need for medical attention, damage to tram and if the security personnel is required. The need for an immediate emergency evacuation has to be assessed. If possible, the driver continues to the next stop and open all doors on the platform side to enable passengers escape the situation.	Safety	* Driver * OCC * Passengers	Safety on board of the tram
OR.03.33	03_Driving	Tram hitting large animals	The driver must stop the vehicle, put on hazard lights and inform OCC of the exact location and direction of travel, and any damage to the tram or infrastructure, then he must assess whether it is safe to continue. the driver also checks if the body catcher was deployed and reset as necessary. If applicable, OCC must inform relevant authorities.	Operation and management	* Driver * OCC * Authorities	N/A
OR.03.34	03_Driving	Persons taken Ill/Injured on tram	Staff who observe anyone taken ill/ injured on the system should call and emergency call OCC immediately. The tram must be stopped where instructed by the CCR, Emergency Services may require the tram at a specific stop. the driver puts the hazard lights on, informs the passengers, and keep OCC informed until arrival of the emergency services.	Operation and management	* Driver * Passengers * OCC * Emergency services * Other staff	Immediate assistance and care to anyone taken ill or injured on the system is provided.
OR.03.35	03_Driving	Child separation, lost minor, person requiring assistance	A driver calls the OCC in Emergency and informs of the exact location and direction of travel and the nature of the emergency. he has to follow instruction of OCC.	Operation and management	* Driver * OCC * Persons involved	Safety and well-being of a person who is lost or separated from their group on the system is ensured.
OR.03.36	03_Driving	Accidents with vehicle or pedestrians	The tram must stop as soon as possible, put the hazard lights on, and the driver must call CCR and inform of the exact location, junction number and direction of travel and issue. Passengers must be informed, the a driver must follow the OCC instructions (e.g., open the doors, which side, detram the passengers, etc.) In the case of a life threatening situation, i.e. a fire on board, an Emergency Evacuation must be arranged in accordance with procedures in order get the passengers off as quickly and as safely as possible.	Safety Operation and management	* Driver * OCC * Passengers * Incident manager	Safety of all passengers are ensured.

OR.03.37	03_Driving	Derailment/ Dewirement	In case of derailment/Dewirement, the tram must stop as soon as possible when it is safe to do so and put hazard lights on. Safety brake must be applied. The driver must call OCC, state the emergency and inform of the exact location, junction number and direction of travel. The passengers must be informed and assesses if they are injured. The damage must be also assessed. After authorisation by the OCC, the passengers must be detramed.	Safety Operation and management	* Driver * OCC * Emergency services * Passengers * Incident manager	Safety of all passengers are ensured.
OR.03.38	03_Driving	Fire on the tram	Evacuation of the tram should be conducted immediately unless it is evident that the fire can quickly be put out using the available fire extinguisher.	Safety Operation and management	* Driver * OCC * Passengers	Safety of all passengers are ensured.
OR.03.39	03_Driving	Driverless Train operation	If driverless train operation is performed, unauthorised entry into the track formation, unauthorised passage over the track formation and unauthorised use of the track formation shall be prevented by enclosure or other means. If it is necessary to ensure the operational safety, the technical supervisory authority may also require such measures along certain route sections of other kinds of track formation.	Safety	* Track infrastructure	N/A
OR.03.40	03_Driving	Equipment that passengers can use in an emergency to initiate braking	Passenger vehicles shall have equipment that passengers can use in an emergency to initiate braking (passenger emergency braking). The actuation of this equipment shall not bring a vehicle to a halt on route sections without safety zones and in tunnels out of stops (passenger emergency braking override). The actuation of the passenger emergency braking equipment shall be indicated to the driver. The passenger emergency braking override may also remain effective on certain other route sections if the operating manager has set up instructions.	Braking	* Emergency braking system * Passengers	Safe driving
OR.03.41	03_Driving	Tram following another tram	A train may only follow another train at such a distance that it can brought to a halt in time, even under the most unfavourable operating conditions, and especially if the train in front of it stops unexpectedly. This distance shall: 1) be effectuated by the driver when driving on sight; 2) be ensured by the train protection system pursuant to Section 22 if the train is operated on a signalled section.	Operation and management	* Driver * Train protection system	Safe driving
OR.03.42	03_Driving	Driving with a safety defect	A train with a safety defect shall not remain in service. If it can continue its journey to a point at which it is convenient to take it out of service from an operational point of view, safety precautions shall be taken according to the nature and severity of the defect. When circumstances so permit, passengers shall be transported to a stop. If a train with a brake defect is moved, it shall be moved at a speed commensurate with the brake power available. If driverless train operation is performed or if the train is operated on a route without a safety zone, precautions shall be taken to ensure that passengers are promptly rescued from trains that cannot continue their journey.	Operation and management	* Driver * ATO system * Passengers	Safe driving
OR.03.43	03_Driving	Identification of the signs and signals	The driver must correctly identify all the signs and signals at any time of the day and at any weather conditions	Perception	* Driver * Signs and signals	N/A
OR.03.44	03_Driving	Identification of objects	The driver must be able to identify various objects along and on the tracks in order to appropriately make a decision.	Perception	* Driver * Objects	N/A
OR.03.45	03_Driving	Use of blinkers	The driver must use blinkers, when necessary, e.g., when swinging form one driving field to another, when exiting roundabouts, when exiting stops	Perception	* Driver * Blinkers	N/A

OR.04.02	04_Parking	Ground marking: tram stop line	The driver must be able to read the ground markings identifying a tram stop line.	Perception	* Driver * Ground markings	The driver is aware of tram stops, including by means of ground markings.
OR.04.03	04_Parking	Platform tram stop position	As practice for the platforms with limited space, a series of painted (bright) dots marked on the platform, on a vertical pole, on floor or as signs indicates the correct stopping position for the tram. Tram drivers must stop at or after the markers, including by using the guide marker in the cab. If the tram is stopped before the platform marker/sign, the side must not be selected and doors must not be release, but the tram must be slowly moved to a correct position. If the tram is stopped after the platform marker/sign, the single door position must be checked.	Perception	* Driver * Markings	The tram stops at the right position.
OR.04.04	04_Parking	Stopping in case of emergency	If required the tram must be stopped as soon as possible when safe to do so, and to wait for instructions from OCC.	Safety	* OCC * OCS * Driver * Other people	N/A
OR.04.05	04_Parking	Partial or complete overrun of a tram stop	The tram must be stopped , and the OCC must be informed of the situation. The OCC will control trams movement in the area.	Decision making	* Driver * OCC * Markings	N/A
OR.04.06	04_Parking	Overcrowding at tram stops or street sections	The OCC must be informed of the situation. The tram must approach the area with extreme caution at a reduced speed, use the chimes or horns, if necessary; be prepared to stop immediately should the path of the tram become obstructed. Passengers to be informed of crowding and to be requested to move away from the doors into the saloon area.	Perception	* Driver * OCC * Passengers * PA * Chimes and horns	The safety of the passengers is provided.
OR.05.01	05_After Parking	Doors management	The doors must only be released once the tram has stopped. If doors must be opened anywhere else, OCC must be consulted. In such a case, the doors may only be opened or released after the driver has alerted the tram passengers.	Door control	* Driver * Doors	The safety of the passengers is provided.
OR.05.02	05_After Parking	Door operation: opening	The door selection can't be commenced before the tram comes to a complete stop.	Door control	* Driver * Doors	The safety of the passengers is provided.
OR.05.03	05_After Parking	Door opening in emergency	Doors shall be kept in their closed position. However, it shall be possible for passengers to open them in an emergency.	Door control	* Driver * Doors * Passengers	The safety of the passengers is provided.

ANNEX 4: USE CASES FOR NON-COMMERCIAL AREAS AND DEPOTS

UC number	Who added the UC	Type	Activity Group	UC Activity Name	UC type	Activity Summary	Context	Applicability: systems	Technology type	Link UC-OPER RULE	Priority	Status (incl. in D5.6)
UC.5.6.1.1	R2DATO	Use Case	Automated data transfer	Reporting defects and faults	Operational	This use case describes how the system automatically reports any defects or faults to the OCC/operations management room as soon as they are detected. This ensures timely and efficient maintenance and repair of the tram.	Non-commercial areas and depots	Urban Rail	Data transfer	OR.00.05	Yes	Incl. in higher level use case
UC.5.6.1.2	R2DATO	Use Case	Automated data transfer	Communicating tram signal number at junctions	Operational	This use case describes how the tram automatically communicates with the OCC at junctions by sending the signal pole number that it recognizes. This enables the OCC to monitor and control the tram's movement and safety.	Non-commercial areas and depots	Urban Rail	Detection and Perception Data transfer	OR.03.04		Not incl.
UC.5.6.2.1	R2DATO	Use Case	Autonomous driving	Coasting	Functional	This use case describes how a tram can operate autonomously by coasting, which means moving without using any power or brakes, and in which conditions.	Non-commercial areas and depots	Urban Rail	Autonomous driving Decision making			Not incl.
UC.5.6.2.2	R2DATO	Use Case	Autonomous driving	Autonomous Parking	Operational	This use case involves the OCC granting permission to a remote operator to park a tram remotely on a vacant track and spot. The remote operator connects to the tram, selects the destination track and spot, commands the tram to move at shunting speed, and monitors the tram's movement until it reaches its final position and comes to a stop.	Non-commercial areas and depots	Urban Rail	Autonomous driving Decision making		Yes	Incl. a modified version
UC.5.6.2.2.1	R2DATO	Use Case	Autonomous driving	Autonomous shunting of several vehicles simultaneously using V2X	Operational	This use case encompasses the simultaneous autonomous shunting of multiple trams, a process designed to enhance operational efficiency, particularly in scenarios requiring tram substitutions, such as directing a malfunctioning tram to the maintenance workshop. To achieve this, V2X technology is used for precise coordination and control of the trams' movements.	Non-commercial areas and depots	Urban Rail	Autonomous driving Decision making V2X		Yes	Yes
UC.5.6.2.3	R2DATO	Use Case	Autonomous driving	Autonomous shunting (outdoor)	Operational	This use case describes how a tram can autonomously shunt, which means moving between parking spaces without a driver.	Non-commercial areas and depots	Urban Rail	Autonomous driving Decision making		Yes	Incl. a modified version
UC.5.6.2.3.1	R2DATO	Use Case	Autonomous driving	Autonomous shunting (from indoor to outdoor)	Operational	This use case involves the autonomous shunting of a tram, allowing it to move between parking spaces without the presence of a driver. The tram transitions from a sheltered indoor area to an outdoor environment. Before initiating movement, the tram conducts a pre-movement self-check. The route is established by a remote operator, and the tram verifies its position and confirms movement with the OCC. The OCC ensures that motorized points are correctly aligned, and the tram checks that the track is clear for movement. Once outside, it adapts its speed and driving style based on environmental conditions and encountered obstacles.	Non-commercial areas and depots	Urban Rail	Autonomous driving Decision making		Yes	Yes
UC.5.6.2.4	R2DATO	Use Case	Autonomous driving	Autonomous shunting (from outdoor to indoor)	Operational	This use case describes how a tram can autonomously shunt, which means moving between parking spaces without a driver, from outdoor to indoor.	Non-commercial areas and depots	Urban Rail	Autonomous driving Decision making		Yes	Incl. a modified version
UC.5.6.2.5	R2DATO	Use Case	Autonomous driving	Acceleration	Functional	This use case describes how a tram can autonomously accelerate. It requires algorithms that can measure the current speed, distance, gradient, and traffic conditions of the track.	Non-commercial areas and depots	Urban Rail	Autonomous driving Decision making			Incl. in higher level use case
UC.5.6.2.6	R2DATO	Use Case	Autonomous driving	Deceleration	Functional	This use case describes how a tram can autonomously decelerate. It requires algorithms that can measure the current speed, distance, gradient, and traffic conditions of the track.	Non-commercial areas and depots	Urban Rail	Autonomous driving Decision making			Incl. in higher level use case

UC.5.6.2.7	R2DATO	Use Case	Autonomous driving	Braking	Functional	This use case describes how a tram can autonomously brake. It requires algorithms that can measure the current speed, distance, gradient, and traffic conditions of the track.	Non-commercial areas and depots	Urban Rail	Autonomous driving Decision making			Incl. in higher level use case
UC.5.6.2.8	R2DATO	Use Case	Autonomous driving	Emergency braking	Operational	This use case describes how a tram can perform emergency braking due to stopping abruptly to avoid a collision or a hazard, while driving autonomously.	Non-commercial areas and depots	Urban Rail	Autonomous driving Decision making			Incl. in higher level use case
UC.5.6.2.9	R2DATO	Use Case	Autonomous driving	Entering/leaving a workshop autonomously	Operational	This use case describes how a tram can enter or leave a workshop autonomously, without a driver. The tram must approach the door and stop, activate the shunting mode, chime, scan the surroundings for obstacles, and then move forward or backward if it is safe. The tram must also communicate with the control centre/operations management room and the workshop staff during the process.	Non-commercial areas and depots	Urban Rail	Autonomous driving Decision making	OR.02.05	Yes	Incl. a modified version
UC.5.6.2.10	R2DATO	Use Case	Autonomous driving	Turning trams in depots	Operational	A tram moves and turns in a depot with approval from the OCC and after making sure the route is clear, avoiding stopping and reversing over points unless necessary, and stops at the assigned position.	Non-commercial areas and depots	Urban Rail	Autonomous driving Decision making	OR.03.09	Yes	Not incl.
UC.5.6.2.11	R2DATO	Use Case	Autonomous driving	Driving at non signalled areas	Operational	A tram slows down and checks for vehicles on the right before crossing a junction without signals.	Non-commercial areas and depots	Urban Rail	Autonomous driving Detection Perception Decision making	OR.03.15		Not incl.
UC.5.6.2.12	R2DATO	Use Case	Autonomous driving	Braking in the event of derailment	Operational	The vehicle stops automatically and immediately if it goes off the track.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making	OR.03.17		Not incl.
UC.5.6.2.13	R2DATO	Use Case	Autonomous driving	Autonomous washing procedure	Operational	The autonomous washing is a process that allows a tram to get washed automatically with the approval and instructions of the OCC/operations management room. Before the washing, the OCC/operations management room establishes the connection with the tram and approves the washing request. The network operator gives specific pre-wash instructions to the OCC/operations management room, such as opening the doors. Some actions still must be done manually on the tram, such as closing windows and hatches. After receiving the green light, the tram moves to the washing point and enters it at shunting speed. The tram undergoes the washing process until it is complete. When exiting the wash, the tram uses the chimes as visibility is restricted. After the washing, the network operator gives specific post-wash instructions, such as closing the doors. If the tram is stopped during the process, the wash stops automatically and does not start again until reset by the OCC/operations management room.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation and monitoring Decision making	OR.03.10	Yes	Incl. a modified version
UC.5.6.3.1	Elastic	Use Case	Driving conditions	Departure in manoeuvring area: at curve or at junction	Functional	The use case of autonomous departure in manoeuvring area describes how a tram can depart from a curve or a junction in a manoeuvring area.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Not incl.
UC.5.6.3.2	Elastic	Use Case	Driving conditions	Departure in shelter at junction	Functional	The use case of autonomous departure in shelter at junction describes how a tram can depart in shelter at junction.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Not incl.

UC.5.6.3.3	Elastic	Use Case	Driving conditions	Departure at line (line sides): at curve, at straight line, at junction	Functional	Describes how a tram can depart from different types of line segments with the approval and guidance of the control centre operator (OCC).	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Not incl.
UC.5.6.3.4	Elastic	Use Case	Driving conditions	Braking in depot (manoeuvring area): at curve, at junction	Functional	The use case describes how a tram can brake safely and smoothly in a depot where it encounters a curve or a junction.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Not incl.
UC.5.6.3.5	Elastic	Use Case	Driving conditions	Braking in depot (shelter) at junction	Functional	The use case describes how a tram can brake safely and smoothly in a shelter where it encounters a junction.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Not incl.
UC.5.6.3.6	Elastic	Use Case	Driving conditions	Braking on a line (line sides): at curve, at straight line, at junction.	Functional	The use case describes how a tram can brake safely and smoothly on a line where it encounters different types of line segments. The tram must adjust its speed and position according to the geometry and the traffic conditions of the curve, the straight line, or the junction. The tram must apply the appropriate braking force and duration to avoid overshooting or undershooting the designated stopping point.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Incl. in higher level use case
UC.5.6.3.7	Elastic	Use Case	Driving conditions	Routing in depot (manoeuvring area): at curve, at straight line, at junction	Functional	The Use case describes how a tram can navigate through different types of depot segments.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Incl. in higher level use case
UC.5.6.3.8	Elastic	Use Case	Driving conditions	Routing on a line (line sides): at curve, at straight line, at junction	Functional	The Use case describes how a tram can navigate through different types of the line segments.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Not incl.
UC.5.6.3.9	Elastic	Use Case	Driving conditions	Tram moving along a straight section of track	Functional	Th use case describes how a tram can travel on a straight-line segment. The tram must monitor the signals and the surroundings for any obstacles or hazards that might require it to stop or slow down. The tram also must adjust its speed and position according to the traffic conditions and signals.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Incl. in higher level use case
UC.5.6.3.10	Elastic	Use Case	Driving conditions	Tram moving along an on-bend section of track	Functional	Use case describes how a tram can travel on a curved line segment. The tram must monitor the signals and the surroundings for any obstacles or hazards that might require it to stop or slow down. The tram also must adjust its speed and position according to the curve geometry and the traffic conditions. The tram must apply the appropriate centripetal force and tilt angle to maintain stability and comfort on the curve.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Not incl.
UC.5.6.3.11	Elastic	Use Case	Driving conditions	Tram moving near other motionless tram	Functional	The use case describes how a tram can travel safely and smoothly near another tram that is not moving. The tram has to adjust its speed and position according to the distance and direction of the motionless tram. The tram has to apply the appropriate braking force and duration to avoid collision or derailment.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Incl. in higher level use case
UC.5.6.3.12	Elastic	Use Case	Driving conditions	Tram moving near other tram moving in the opposite direction	Functional	The use case describes how a tram can travel safely and smoothly near another tram that is moving in the opposite direction. The tram also has to adjust its speed and position according to the distance and direction of the other tram. The tram has to apply the appropriate braking force and duration to avoid collision or derailment.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Not incl.
UC.5.6.3.13	Elastic	Use Case	Driving conditions	Operating in morning time lighting	Functional	The use case describes how a tram can adapt to the changing light conditions in the morning.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Incl. in higher level use case

UC.5.6.3.14	Elastic	Use Case	Driving conditions	Operating in midday time lighting	Functional	The use case describes how a tram can adapt to the changing light conditions in the midday.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Incl. in higher level use case
UC.5.6.3.15	Elastic	Use Case	Driving conditions	Operating in twilight time lighting	Functional	The use case describes how a tram can adapt to the changing light conditions in the twilight time.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Incl. in higher level use case
UC.5.6.3.16	Elastic	Use Case	Driving conditions	Operating in night-time lighting	Functional	The use case describes how a tram can adapt to the changing light conditions in the night-time.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Incl. in higher level use case
UC.5.6.3.17	Elastic	Use Case	Driving conditions	Operating in presence of reflexes in surroundings (shop windows, windows, doors, cars…)	Functional	The Use case describes how a tram can cope with the possible reflections or distortions caused by shiny or transparent surfaces in the environment.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Not incl.
UC.5.6.3.18	Elastic	Use Case	Driving conditions	Operating in sunny day	Functional	The Use case describes how a tram can operate in bright and clear weather conditions.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Incl. in higher level use case
UC.5.6.3.19	Elastic	Use Case	Driving conditions	Operating in rainy day (light raining)	Functional	The Use case describes how a tram can operate in light raining conditions.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Incl. in higher level use case
UC.5.6.3.20	Elastic	Use Case	Driving conditions	Operating in rainy day (thick fog)	Functional	The Use case describes how a tram can operate in heavy rain and foggy conditions.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Incl. in higher level use case
UC.5.6.3.21	Elastic	Use Case	Driving conditions	Operating in snowy day	Functional	The Use case describes how a tram can operate in snowy conditions.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making			Not incl.
UC.5.6.2.14	R2DATO	Use Case	Autonomous driving Control	Wrong directional moves	Operational	To move in the wrong direction, the tram (or the remote operator in remote driving mode) has to get authorisation from the OCC/operations management and confirm the intention to do so. The OCC/operations management also has to check the points before the tram moves and switch to the leading cab remotely. The tram or the remote operator has to check the surroundings using the perception system or the cameras and sensors in remote driving mode and make sure that there are no trams or people on the tracks.	Non-commercial areas and depots	Urban Rail	Autonomous driving Observation Decision making	OR.03.11	No	Not incl.
UC.5.6.4.1	R2DATO	Use Case	Communication	Initiate (data) communication between the tram and the OCC	Functional	The UC describes how the tram connect OCC/operations management when it is connected and in operation. When tram contacts OCC /operations management room, OCC/operations management room must automatically define which tram contacted them and where it is located. If the tram does not receive any confirmation from OCC/operations management room, it must repeat the attempt as many times as specified by the network operator. All transmitted information has to be confirmed from both sides in bi-directional communication.	Non-commercial areas and depots	Urban Rail	Communication	OR.00.01		Incl. in higher level use case
UC.5.6.4.2	R2DATO	Use Case	Communication	Conclude (data) communication between the tram and the OCC	Functional	The UC describes how communications are concluded by OCC/operations management room.	Non-commercial areas and depots	Urban Rail	Communication			Incl. in higher level use case

UC.5.6.4.3	R2DATO	Use Case	Communication	Data sharing	Functional	The UC describes how the data from the vehicle is shared with the stakeholders.	Non-commercial areas and depots	Urban Rail	Communication			Not incl.
UC.5.6.4.4	R2DATO	Use Case	Communication	After pre-departure check readiness	Operational	The tram has to complete a pre-departure check before leaving the depot. If the check is successful, the tram has to contact the control centre operator (OCC)/operations management and ask for permission to go to the depot gate. There, the tram has to follow the instructions from the network operator, who requests the tram to select the route and enter the main line. After getting the confirmation from the OCC, the tram has to input RTS, check visibility and start moving.	Non-commercial areas and depots	Urban Rail	Autonomous driving Communication	OR.02.01		Incl. in higher level use case
UC.5.6.4.5	R2DATO	Use Case	Communication	Authorisation of tram movements within depot	Functional	Personnel (shunting, washing, maintenance) via remote control centre requests OCC/operations management to authorise a tram movement.	Non-commercial areas and depots	Urban Rail	Communication	OR.02.02	Yes	Incl. in higher level use case
UC.5.6.5.1	R2DATO	Use Case	Control	Connecting to the vehicle	Functional	Description of the process, how a remote operator connects to a chosen tram vehicle.	Non-commercial areas and depots	Urban Rail	Communication			Incl. in higher level use case
UC.5.6.4.6	R2DATO	Use Case	Communication	Establishing remote driving mode	Functional	This use case represents the functionality, where a tram within the depot is switched on from the OCC remote driving control centre.	Non-commercial areas and depots	Urban Rail	Communication			Incl. in higher level use case
UC.5.6.5.2	R2DATO	Use Case	Control	Telecommand: turning off the vehicle	Functional	The UC describes how the tram can be turned off remotely.	Non-commercial areas and depots	Urban Rail	Communication		Yes	Incl. in higher level use case
UC.5.6.5.3	R2DATO	Use Case	Control	Telecommand of the driver's functions	Operational	This use case describes how to remotely control, or telecommand, all the possible driver's functions of a tram, such as control of the HMI interface, accelerating, braking, steering, signalling, etc. Some of the basic examples of telecommand are also presented in this list of use cases.	Non-commercial areas and depots	Urban Rail	Telecommand		Yes	Incl. in higher level use case
UC.5.6.5.4	R2DATO	Use Case	Control	End of service: disconnecting from the vehicle	Functional	This case of use refers to the moment when the manoeuvres and actions with the tram are finished and Remote-control centre must switch off and disconnect the vehicle. Description of the process, how the remote operator disconnects from the chosen tram vehicle.	Non-commercial areas and depots	Urban Rail	Communication			Incl. in higher level use case
UC.5.6.5.5	R2DATO	Use Case	Control	Perform video streaming	Functional	The UC describes how the video steaming is initiated and performed in the tram.	Non-commercial areas and depots	Urban Rail	Communication			Incl. in higher level use case
UC.5.6.5.6	R2DATO	Use Case	Control	Vehicle positioning	Functional	The UC describes how the position of the vehicle is defined and verified.	Non-commercial areas and depots	Urban Rail	Communication			Incl. in higher level use case
UC.5.6.5.7	R2DATO	Use Case	Control	Remote set up of the tram's route	Functional	The UC describes how the route for the tram is set up remotely.	Non-commercial areas and depots	Urban Rail	Communication			Incl. in higher level use case

UC.5.6.5.8	R2DATO	Use Case	Control	Telecommand of the tram cab key control	Functional	Remote control of the tram cab key: turning on, turning off and switching to various regimes. The control has the following modes: - Driver key on NM; Normal mode. Used for general driving. - Driver key on P; Used when performing a tram re-prep - Driver key on N; Neutral mode. The cab is not active. - Driver key on SM; Shunt mode. Used in the depot for running trams through the wash, in/out of the workshops, and during the procedure to couple trams for tow and push. In SM the speed is automatically limited to the one defined by the network operator. - Driver key on NM and push reverse PBLI (Push-Button Latching Type Illuminated). Reverse mode speed is automatically limited to the one defined by the network operator. The reverse mode operation has to follow a specific procedure defined by the operator. The tram can be controlled either from the cabin or remotely, but not both at the same time.	Non-commercial areas and depots	Urban Rail	Communication	OR.03.05	Yes	Incl. in higher level use case
UC.5.6.5.9	R2DATO	Use Case	Control	Control of the exterior lights	Functional	A remote tram operator can adjust the brightness of the exterior lights according to the ambient light level and the traffic conditions. The tram can also turn on or off the exterior lights as needed or instructed.	Non-commercial areas and depots	Urban Rail	Telecommand			Incl. in higher level use case
UC.5.6.5.10	R2DATO	Use Case	Control	Control of the interior lights	Functional	A remote tram operator can adjust the brightness of the interior lights according to the ambient light level and the passenger comfort. The tram can also turn on or off the interior lights as needed or instructed.	Non-commercial areas and depots	Urban Rail	Telecommand			Incl. in higher level use case
UC.5.6.5.11	R2DATO	Use Case	Control	Control of the pantograph	Functional	A remote tram operator can raise or lower the pantograph to connect or disconnect from the overhead power line.	Non-commercial areas and depots	Urban Rail	Telecommand			Incl. in higher level use case
UC.5.6.5.12	R2DATO	Use Case	Control	Control of HMI interface and buttons	Functional	A remote tram operator tram can use the human-machine interface (HMI) and buttons to display information, receive inputs, and perform actions.	Non-commercial areas and depots	Urban Rail	Telecommand			Incl. in higher level use case
UC.5.6.5.13	R2DATO	Use Case	Control	Control of wipers and washers	Functional	A remote tram operator can use the wipers and washers to clean the windshield and improve visibility. They can also adjust the speed and frequency of the wipers and washers according to the weather conditions and the dirt level.	Non-commercial areas and depots	Urban Rail	Telecommand			Incl. in higher level use case
UC.5.6.5.14	R2DATO	Use Case	Control	Control of sound signals	Functional	A remote tram operator can use sound signals to warn, alert, or communicate with other trams and people.	Non-commercial areas and depots	Urban Rail	Telecommand			Incl. in higher level use case
UC.5.6.5.15	R2DATO	Use Case	Control	Activate winter heating parking mode	Functional	A remote tram operator can activate winter heating parking mode to prevent freezing or damage to the tram components during cold weather.	Non-commercial areas and depots	Urban Rail	Telecommand			Incl. in higher level use case
UC.5.6.5.16	R2DATO	Use Case	Control	Remote control of braking	Functional	The tram can be controlled remotely by a remote operator who can apply braking force and duration to stop or slow down the tram. The remote operator can also monitor the braking status and performance of the tram.	Non-commercial areas and depots	Urban Rail	Telecommand			Incl. in higher level use case
UC.5.6.5.17	R2DATO	Use Case	Control	Activating the emergency braking	Operational	The tram can activate emergency braking when it detects an imminent collision or derailment risk. The tram can also alert other trams and people in surroundings bout its emergency braking.	Non-commercial areas and depots	Urban Rail	Telecommand			Incl. in higher level use case
UC.5.6.5.18	R2DATO	Use Case	Control	Remote control of driving: acceleration	Functional	The tram can be controlled remotely by a remote operator who can apply acceleration force and duration to increase speed or change direction. The remote operator can also monitor the acceleration status and performance of the tram.	Non-commercial areas and depots	Urban Rail	Telecommand			Incl. in higher level use case

UC.5.6.5.19	R2DATO	Use Case	Control	Remote control of driving: controlled driving	Functional	The tram can be controlled remotely by a remote operator who can follow a predefined route and direction while adjusting speed and position according to traffic conditions and signals. The remote operator can also monitor the driving status and performance of the tram.	Non-commercial areas and depots	Urban Rail	Telecommand			Incl. in higher level use case
UC.5.6.5.20	R2DATO	Use Case	Control	Remote control of driving: deceleration	Functional	The tram can be controlled remotely by a remote operator who can apply deceleration force and duration to decrease speed. The remote operator can also monitor the deceleration status and performance of the tram.	Non-commercial areas and depots	Urban Rail	Telecommand			Incl. in higher level use case
UC.5.6.5.21	R2DATO	Use Case	Control	Control of motorised points	Operational	The tram can control motorised points to switch between different tracks or directions.	Non-commercial areas and depots	Urban Rail	Telecommand		No	Incl. in higher level use case
UC.5.6.5.22	R2DATO	Use Case	Control	Vigilance device (Deadman function) activation/deactivation	Functional	When the tram is set up in autonomous driving mode, a vigilance device must be automatically deactivated, but a supervision system turns on.	Non-commercial areas and depots	Urban Rail	Autonomous driving Telecommand	OR.01.02		Incl. in higher level use case
UC.5.6.5.23	R2DATO	Use Case	Control Communication	Unintended train separation	Operational	At the event of unintended train separation, the trams must be braked automatically. The information on the train separation must be communicated automatically to the OCC.	Non-commercial areas and depots	Urban Rail	Decision making	OR.03.16	No	Not incl.
UC.5.6.5.24	R2DATO	Use Case	Control	Remote driving: parking	Operational	This use case involves the OCC giving permission to a remote operator to remotely park a tram on a free track and spot. The remote operator connects to the tram, selects the destination track and spot, commands the tram to move at shunting speed, and monitors the tram's movement until it reaches its final position and stops	Non-commercial areas and depots	Urban Rail	Telecommand		Yes	Yes
UC.5.6.5.25	R2DATO	Use Case	Control	Remote washing	Operational	The remote tram washing process allows a tram to be washed remotely with approval and instructions from the OCC. The process involves establishing a connection with the tram, obtaining approval for washing, receiving pre-wash instructions from the OCC, performing manual actions on the tram, such as closing windows and hatches, moving to the washing point, undergoing the washing process, using chimes (or bells) for visibility upon exit, and receiving post-wash instructions from the OCC. If the tram stops during the process, the wash stops automatically and requires reset by the OCC.	Non-commercial areas and depots	Urban Rail	Telecommand		Yes	Yes
UC.5.6.6.1	R2DATO	Use Case	Decision making	Speed regulation	Functional	The tram can decide how to regulate its speed according to signals and weather. The tram can also monitor its speed performance and detect any faults or deviations.	Non-commercial areas and depots	Urban Rail	Decision making		Yes	Incl. in higher level use case
UC.5.6.6.2	R2DATO	Use Case	Decision making	Determining optimal speed	Functional	The tram can decide what is the optimal speed for its current route and direction, taking into account the road conditions, signals, and weather.	Non-commercial areas and depots	Urban Rail	Decision making			Incl. in higher level use case
UC.5.6.6.3	R2DATO	Use Case	Decision making	Scenarios of use of chimes and horns	Functional	The tram decides when and how to use chimes and horns to warn and alert other trams, vehicles, and people in the surroundings.	Non-commercial areas and depots	Urban Rail	Decision making			Incl. in higher level use case
UC.5.6.6.4	R2DATO	Use Case	Decision making	Analysis of the environment for detection of the factors affecting accelerating or braking capacity	Functional	The system must analyse the environment to trigger adjusting speed, acceleration, and braking. The factors influencing adjusting driving style are falling leaves, dew, rain, mist, fog, flooding, snow, presence of road vehicles.	Non-commercial areas and depots	Urban Rail	Decision making	OR.03.06		Incl. in higher level use case

UC.5.6.6.5	R2DATO	Use Case	Decision making	Actions in emergency situations	Functional	The use case describes the tram actions in emergency situations according to pre-programmed scenarios.	Non-commercial areas and depots	Urban Rail	Decision making			Not incl.
UC.5.6.7.1	R2DATO	Use Case	Detection	Detection of other vehicles, including the ones on other tracks	Functional	Identifying and tracking the location, speed, and direction of nearby vehicles that may pose a collision risk.	Non-commercial areas and depots	Urban Rail	Detection and Perception			Incl. in higher level use case
UC.5.6.7.2	Elastic	Use Case	Detection	Static obstacle between the rails: the height of the object is lower than the height of the lower part of the tram	Functional	Detecting and ignoring objects that are too low to interfere with the tram's movement.	Non-commercial areas and depots	Urban Rail	Detection and Perception			Incl. in higher level use case
UC.5.6.7.3	Elastic	Use Case	Detection	Static obstacle between the rails: the height of the object is higher than the height of the lower part of the tram	Functional	Detecting objects that are high enough to cause damage or derailment to the tram.	Non-commercial areas and depots	Urban Rail	Detection and Perception			Incl. in higher level use case
UC.5.6.7.4	Elastic	Use Case	Detection	Static harmful obstacle on the track rails. A rock, a bicycle, a car, a person, a fallen branch of a tree, a bunch of snow, could be such obstacles	Functional	Detecting and stopping at objects that could harm the tram.	Non-commercial areas and depots	Urban Rail	Detection and Perception			Incl. in higher level use case
UC.5.6.7.5	Elastic	Use Case	Detection	Static harmless obstacle on the track rails. Newspapers, leaves, empty plastic bags, a snow thin layer, shallow pool of water, could be such obstacles	Functional	Detecting and ignoring objects that do not affect the tram's performance or safety.	Non-commercial areas and depots	Urban Rail	Detection and Perception			Incl. in higher level use case
UC.5.6.7.6	Elastic	Use Case	Detection	Obstacle moving along the rail. Its size is sufficient for impacting with tram	Functional	Detecting objects that are moving in the same direction as the tram and are large enough to collide with it.	Non-commercial areas and depots	Urban Rail	Detection and Perception			Incl. in higher level use case
UC.5.6.7.7	Elastic	Use Case	Detection	Obstacle moving along the rail. Even if size is not sufficient for impacting with tram, its trajectory is too close and dangerous	Functional	Detecting objects that are moving in the same direction as the tram but are too close to the rails or have unpredictable movements.	Non-commercial areas and depots	Urban Rail	Detection and Perception			Incl. in higher level use case
UC.5.6.7.8	Elastic	Use Case	Detection	Obstacle moving at a distance from the tram, but its trajectory and vehicles speed is compatible with a future collision	Functional	Detecting and anticipating objects that are moving in a different direction than the tram but could cross its path in the future.	Non-commercial areas and depots	Urban Rail	Detection and Perception			Incl. in higher level use case
UC.5.6.7.9	Elastic	Use Case	Detection	Possible obstacle recognition, among categories such as: adult human being, children, dogs, bicycles, motorbikes, cars, trams, buses, lorries, horses, horse drawn carriages	Functional	Classifying and labelling objects based on their appearance and behaviour, such as human, animal, vehicle, etc.	Non-commercial areas and depots	Urban Rail	Perception			Incl. in higher level use case

UC.5.6.7.10	R2DATO	Use Case	Detection	Track Clearance Check	Functional	Before any movements, the tram verifies that the track ahead is clear of any objects that could obstruct its movement or pose a safety hazard. No object must be allowed to cross the yellow lines that mark the driving profile.	Non-commercial areas and depots	Urban Rail	Detection and Perception	OR.02.07		Incl. in higher level use case
UC.5.6.8.1	R2DATO	Use Case	Observation and Monitoring	Continuous analysis of the environment: moving people, vehicles, appearance of an obstacle	Functional	Monitoring the surroundings of the tram while moving and detecting any changes or events that could affect its operation or safety.	Non-commercial areas and depots	Urban Rail	Observation and monitoring			Incl. in higher level use case
UC.5.6.8.2	R2DATO	Use Case	Observation and Monitoring	Analysis of weather conditions	Functional	Evaluating the current and forecasted weather conditions and adjusting the tram's speed, braking, and traction accordingly while driving.	Non-commercial areas and depots	Urban Rail	Observation and monitoring			Incl. in higher level use case
UC.5.6.8.3	R2DATO	Use Case	Observation and Monitoring	Analysis of track conditions	Functional	While driving, assessing the state of the track, and identifying any defects, damages, or hazards that could impair the tram's performance or stability.	Non-commercial areas and depots	Urban Rail	Observation and monitoring		No	Not incl.
UC.5.6.8.4	R2DATO	Use Case	Observation and Monitoring	Analysis of road type: curve, junction, straight line, etc.	Functional	Analysing and recognising the shape and layout of the track and anticipating any turns, intersections, or other features that require special attention or action.	Non-commercial areas and depots	Urban Rail	Observation and monitoring			Not incl.
UC.5.6.8.5	R2DATO	Use Case	Observation and Monitoring	Continuous self-monitoring on any failures	Functional	Checking the status and functionality of the tram's components and systems and reporting any errors, malfunctions, or failures to the remote driver or operations management/OCC.	Non-commercial areas and depots	Urban Rail	Observation and monitoring			Incl. in higher level use case
UC.5.6.9.1	R2DATO	Use Case	Perception	Analysis of sensor data of the tram sensors	Functional	Processing and interpreting the data collected by the tram's sensors and cameras and using it to create a comprehensive representation of the tram's situation and environment.	Non-commercial areas and depots	Urban Rail	Perception			Not incl.
UC.5.6.9.2	R2DATO	Use Case	Perception	Signal detection and recognition	Functional	The ATO system must visually recognise the following types of signals in order to inform the tram's behaviour: - movement signals: e.g., stop (+unless too close to stop safely), triggering proceeding if safe to do so; - signals indicating a tram proceed authorisation: e.g., triggering proceeding left/right if safe to do so; - signals indicating fault/failure: e.g., STOP blank/no signal and single dot --> the tram must contact OCC/operations management room for further instructions; - indicator lamp to acknowledge receipt of the request; - point position indicators: point set to the left, point position is not detected, point is set to the right; - shunting signals (e.g., red/light signals in depots); - track number signal (when entering parking area)	Non-commercial areas and depots	Urban Rail	Perception	OR.03.01		Incl. in higher level use case
UC.5.6.9.3	R2DATO	Use Case	Perception	Signs detection and recognition	Functional	The ATO system must recognise the following types of signs: - speed sign; - stop sign - yield sign (yield right of way to another light rail vehicle or to traffic on a road ahead); - other instructions signs, defined by the operator; - instruction signs: turning point; - coasting zones signs (e.g., SI locations); - signs forbidding any trams on the section	Non-commercial areas and depots	Urban Rail	Perception	OR.03.02		Incl. in higher level use case
UC.5.6.4.7	R2DATO	Use Case	Communication	Signal and sign detection and recognition with V2X communication	Functional	The tram equipped with ATO and V2X technology communicates with the signalling infrastructure using either WLAN-based or cellular-based V2X communication. It receives real-time information about the traffic signal status, the speed limit, the road condition, etc. The received information triggers adjusting its speed, acceleration, and braking.	Non-commercial areas and depots	Urban Rail	Communication			Incl. in higher level use case

UC.5.6.10.1	R2DATO	Use Case	Self-check	Self-checking of window wipers and liquid	Functional	Verifying the functionality and availability of the window wipers and the liquid that cleans the windows.	Non-commercial areas and depots	Urban Rail	Self-check			Incl. in higher level use case
UC.5.6.10.2	R2DATO	Use Case	Self-check	Self-checking of front lights	Functional	Ensuring the proper operation and brightness of the front lights that illuminate the track ahead.	Non-commercial areas and depots	Urban Rail	Self-check			Incl. in higher level use case
UC.5.6.10.3	R2DATO	Use Case	Self-check	Wheel profile examination	Operational	This use case involves the remote operator establishing a connection with a tram and following specific instructions for wheel profile examination. The remote operator initiates laser measurements and controls the tram to move at shunting speed until all the wheels pass through the laser. After the measurement, they complete specific protocols defined by the network operator.	Non-commercial areas and depots	Urban Rail	Self-check		Yes	Yes
UC.5.6.10.4	R2DATO	Use Case	Self-check	Telecommand: visibility check	Functional	Before any movements, proper visibility must be ensured. The following items must be checked by the system: defrost function, camera views, sensors, etc. Before the operation, manually, window cleanliness has to be checked by the drivers (tram attendants).	Non-commercial areas and depots	Urban Rail	Self-check	OR.03.12		Incl. in higher level use case
UC.5.6.10.5	R2DATO	Use Case	Self-check	Pre-departure tram check	Operational	A tram has to be set up in "P "mode to be prepared. While the tram is being prepared, need to check all safety equipment and seals being present. Then, in NM mode, a tram has to go through a pre-departure checklist defined by each network operator. It includes checking such tram systems as: external lights, chimes & horns, all lights, wipers & washer, PA, doors open and close, safety break, track brake, console indicator lamps work, traction, functionality of mirror cameras, pantograph raised, control of alarms on TCMS-HMI monitors or alarm lamps on driver desk. What has to be checked by the personnel manually: all safety equipment and seals being present, saloon (visual check, i.e., i.e. floor is clean, dry and clear of any obstructions, emergency handle covers in place, overhead panels are secure, and inspect widows for defects, seal on the first aid kit box, seal on fire extinguisher, if switch iron for manual operation of the switches is on place, inside of the vehicle for graffiti and damages), outside of the vehicle for graffiti and damages.	Non-commercial areas and depots	Urban Rail	Self-check	OR.01.01	Yes	Yes
UC.5.6.10.6	R2DATO	Use Case	Self-check	Check list for moving inside, outside, entering or exiting the workshop	Operational	When the tram was requested to move inside or outside the workshop, it has to check automatically: power is on, red light illuminated, crane is not in the way, no person is working on or near the tram, tram is not coupled to another tram, and manually: no tags indicating it cannot be moved, no scotches under wheels, body catchers are raised, all panels are secured.	Non-commercial areas and depots	Urban Rail	Self-check	OR.02.03		Incl. in higher level use case