# X2Rail-4

| | |
|---|---|
| Project Title: | Advanced signaling and automation system – Completion of activities for enhanced automation systems, train integrity, traffic management evolution and smart object controllers. |
| Starting date: | 01/12/2019 |
| Duration in months: | 36 |
| Call (part) identifier: | S2R-CFM-IP2-01-2019 |
| Grant agreement no: | 881806 |

# Deliverable D3.2
# GoA3/4 Specification

| | |
|---|---|
| Due date of deliverable | Month 18 |
| Actual submission date | 15-12-2021 |
| Organization name of lead contractor for this deliverable | ALS |
| Dissemination level | PU |
| Revision | 0.1.0ter |
| Revision date | 08-03-2022 |

**Disclaimer: This working version has been issued for the specific use of Shift2Rail activities, as deliverable of WP3 of the X2Rail-4 project (activity funded under the Grant Agreement number 881806). It shall not be used as a reference for any other purpose since it does not represent a release version legally binding.**

*Deliverable template version: 01 (21/04/2020)*

# Authors & Version Management


| | | |
|---|---|---|
| **Author(s)** | **ALS** Stéphane Besure | |
| **Contributor(s)** | **BTSE** Asad Javed | |
| | **STS** Michele Bruzzo | |
| | **RFI** Diana Serra | |
| | **AZD** Michal Novak | |
| | **CAFS** Paul Bretos | |
| | **MERMEC** Giuseppe Pagliarulo | |
| | **SMO** Andreas Steingroever | |
| | **TD** Hans Georg Kast | |
| | **SNCF** Isabelle Chevaleyre | |
| | **SBB** Xiaolu Rao | |
| | **DB** Simon Heller | |
| | **NR** Richard Deacon | |
| | **EUG** Arvid Baarnhielm | |

| Version Management | | |
|---|---|---|
| **Version Number** | **Modification Date** | **Description / Modification** |
| 0.0.1 | 22-01-2019 | New document<br>X2R-1 reference: X2R-T4.7-D-ALS-001-01 |
| 0.0.2 | 05-04-2019 | New chapter 8 Use Cases |
| 0.0.3 | 20-05-2019 | The document structure and content has been changed according to the following minutes of ATO workshops:<br>X2R – GoA3_4 – Minutes of Meeting – 19 01 23<br>X2R – GoA3_4 – Minutes of Meeting – 19 02 20<br>X2R – GoA3_4 – Minutes of Meeting – 19 03 23<br>X2R – GoA3_4 – Minutes of Meeting – 19 04 24 |
| 0.0.4 | 05-07-2019 | The document content has been changed according to the following minutes of ATO workshop:<br>X2R – GoA3_4 – Minutes of Meeting – 19 06 19 |
| 0.0.5 | 08-11-2019 | The document content has been changed according to the following minutes of ATO workshop:<br>X2R – GoA3_4 – Minutes of Meeting – 19 08 21<br>X2R – GoA3_4 – Minutes of Meeting – 19 09 11<br>X2R – GoA3_4 – Minutes of Meeting – 19 10 23<br>Chapter 8 completed with new Use Cases related to operational degraded modes. |
| 0.0.6 | 03-03-2020 | The document content has been changed according to the following minutes of ATO workshop:<br>X2R – GoA3_4 – Minutes of Meeting – 19 12 18<br>X2R – GoA3_4 – Minutes of Meeting – 20 02 05<br>New chapter 4 General principles |
| 0.0.7 | 23-03-2020 | The document content has been changed according to the following minutes of ATO workshop:<br>X2R – GoA3_4 – Minutes of Meeting – 20 03 05<br>Functional exchanges added to interfaces. |

| | | |
|---|---|---|
| 0.0.8 | 03-07-2020 | The document content has been changed according to the following minutes of ATO workshop:<br>X2R – GoA3_4 – Minutes of Meeting – 20 03 25<br>X2R – GoA3_4 – Minutes of Meeting – 20 04 28<br>X2R – GoA3_4 – Minutes of Meeting – 20 05 27<br>New X2R-4 reference: X2R4-WP03-D-ALS-009-01 |
| 0.0.9 | 20-10-2020 | The document content has been changed according to the following minutes of ATO workshop:<br>X2R – GoA3_4 – Minutes of Meeting – 20 07 08 |
| 0.0.10 | 01-12-2020 | The document content has been changed according to the following minutes of ATO workshop:<br>X2R – GoA3_4 – Minutes of Meeting – 20 09 09<br>X2R – GoA3_4 – Minutes of Meeting – 20 09 30<br>X2R – GoA3_4 – Minutes of Meeting – 20 10 21 |
| 0.0.11 | 09-02-2021 | The document content has been changed according to the following minutes of ATO workshop:<br>X2R – GoA3_4 – Minutes of Meeting – 20 12 02<br>X2R – GoA3_4 – Minutes of Meeting – 21 01 13 |
| 0.0.12 | 08-03-2021 | The document content has been changed according to the following minutes of ATO workshop:<br>X2R – GoA3_4 – Minutes of Meeting – 21 02 10<br>Chapters 5, 6, 7, 8, 9, 10, 11, 12 were modified and new chapters 1, 4, 13, 14 were introduced according to new X2R template. |
| 0.0.13 | 20-04-2021 | The document content has been changed according to the following minutes of ATO workshop:<br>X2R – GoA3_4 – Minutes of Meeting – 21 03 09<br>Chapters 3, 5, 6, 7, 8, 9, 10, 11, 12 were modified. |
| 0.0.14 | 04-05-2021 | The document content has been changed according to the following minutes of ATO workshop:<br>X2R – GoA3_4 – Minutes of Meeting – 21 04 21 |

| | | |
|---|---|---|
| | | A new chapter 6 “System description” was added and chapters 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 15 were modified. |
| 0.1.0 | 04-05-2021 | Version modification for D.3.2 deliverable. |
| 0.1.0bis | 13-12-2021 | Addition of the “DRAFT” watermark. Addition of the disclaimer on the cover page. |
| 0.1.0ter | 08-03-2022 | Dissemination level corrected to PU according to project Grant Agreement. |

# 1 Executive Summary

The deliverable D3.1 “GoA2 specification” and D3.2 “GoA34 specification” collect the operator needs associated to the different Grade of Automation levels of ATO and define a standard solution for WP4 “ATO up to GoA4” Development.

The deliverable D3.2 uses a semi-formal method to specify the new GoA34 system with the support of a modelling tool shared between the operators and the suppliers. Starting from the Use Cases defined in the group, it defines the system functions necessary to answer to the various needs and uses a reference architecture to implement them into dedicated logical components. Two components are added to GoA2 architecture to implement the various functions performed today by a driver in the Main Lines applications: PER component emulates the perception of the driver while IPM component emulates its behaviour in case of incident.

The deliverable D3.2 is generated automatically from the GoA34 model via a specific template that extracts the relevant information for each chapter. Interoperable or exchangeable logical interfaces are generated automatically from the data flows exchanged between the functions allocated to the logical components. Several physical implementations are then possible to offer a maximum flexibility for applications.

The deliverable D3.2 will continue to evolve to take into account the results of the test tracks and safety analyses before to become a European standard like TSI 2022 for D3.1.

# 2 Table of Contents

# 3 Abbreviations and acronyms

| Abbreviation / Acronyms | Description |
|---|---|
| AoE | ATO over ETCS |
| ASR | Additional Speed Restriction |
| ATO | Automatic Train Operation |
| ATP | Automatic Train Protection |
| CL | Contact Line |
| CNG | Compressed Natural Gas |
| DAC | Digital Automatic Coupler |
| DAS | Driver Advisory System |
| DM | Digital Map |
| DMU | Diesel Multiple Unit |
| EMU | Electrical Multiple Unit |
| ERATV | European Register of Authorised Types of Vehicles |
| ES | Exchange Scenario |
| ETCS | European Train Control System |
| FFFIS | Form Fit Functional Interface Specification |
| FIS | Functional Interface Specification |
| FS | Full Supervision |
| GoA | Grade of Automation |
| IPM | Incident and Prevention Management |
| JP | Journey Profile |
| LS | Light Signal |

| | |
|---|---|
| LZ | Localization |
| MP | Mission Profile |
| NVR | National Vehicle Register |
| OC | Operational Context |
| OCL | Overhead Contact Line |
| ORD | On-board Recording Device |
| OS | On-Sight |
| PE | Physical Environment |
| PER | Perception |
| PMR | Person with Reduced Mobility |
| RINF | Register of Infrastructure |
| RU | Railway Undertaking |
| RV | ReVerse |
| SCV | Signal ConVerter |
| SH | SHunting |
| SIL | Safety Integrity Level |
| SP | Segment Profile |
| SR | Staff Responsible |
| TBD | To Be Defined |
| TBL | Traction Braking Lever |
| TCMS | Train Control and Monitoring System |
| TIS | Transport Information System |
| TP | Timing Point |

| | |
|---|---|
| TPS | Train Preparation Staff |
| TSI | Technical Specifications for Interoperability |
| TSI TAF | TSI Telematics Applications for Freight |
| TSI TAP | TSI Telematics Applications for Passengers |
| TSR | Temporary Speed Restriction |
| UC | Use Case |
| VD | Vehicle Diagnosis |

# 4 Background

The European Railways are currently in the process of implementing ERTMS. A further step in achieving improved capacity, on-time performance and opportunities to realise energy efficiency improvements is to develop and implement Automatic Train Operation (ATO) over ETCS (AoE).

AoE covers a wide range of applications from manually assisted to fully automated train operation. Possible actual operation depends on the desired grade of automation (GoA) and the automation level supported by IM on a specific route.

The definition of GoA arises from apportioning responsibility for the given functions of railway operations between operational staff and involved technical railway systems. The table below defines the operation principles for each GoA level.

| GoA | GoA Name | Train Operator | Description |
|---|---|---|---|
| **GoA1** | **Non automated train operation** | Train driver in the cab | The train is driven manually; but protected by automatic train protection (ATP). This GoA can also include providing advisory information to assist manual driving. |
| **GoA2** | **Semi-automated train operation** | Train driver in the cab | The train is driven automatically, stopping is automated but a driver in the cab is required to start automatic driving of the train, the driver can operate the doors (although this can also be done automatically), the driver is still in the cab to check the track ahead is clear and carry out other manual functions. The driver can take over in emergency or degraded situations. |
| **GoA3** | **Driverless train operation** | Train attendant on-board the train | The train is operated automatically including automatic departure, a train attendant has some operational tasks, e.g. operating the train doors (although this can also be done automatically) and can assume control in case of emergency or degraded situations. |
| **GoA4** | **Unattended train operation** | No staff on-board competent to operate the train | Unattended train operation; all functions of train operation are automatic with no staff on-board to assume control in case of emergencies or degraded situations. |

**Table 4.1 – Grades of Automation high level description**

Even though the highest Grade of Automation is a proven technology in Urban operations, the operational constraints of a mainline transport system are significantly more complex than those of urban systems:

- The track layout is larger and more complex;
- The roll-out of any new system across the network takes many years, resulting in most journeys spanning lines with significantly different levels of fitment of infrastructure;
- There is a lot of different train types (with different performance levels and door layouts);
- Most trains are not all dedicated to a particular line; they may go anywhere in the country, with a few running anywhere in Europe;
- The absolute exclusion of people (as well as animals and other obstructions) from tracks is not practically achievable throughout a national network, that would mean vast lengths of fencing to install and maintain;

- Infrastructure Managers (IMs) and Railway Undertakings (RUs: train owners and operators) are often independent (at least in the European Union), and sometimes other parties are also involved, such as train leasing companies.

Despite the specificities of Main Lines, Automated Train Operation (up to GoA4) will be undoubtedly beneficial for the different kinds of railway operation:

- For High Speed Trains, Intercity lines, and Regional lines, Semi-Automated Operation (at least GoA2) will enhance the time-table adherence and optimise energy consumption;
- For Freight lines, both on heavy haul railroads and low density traffic lines, ATO (at least GoA2) will provide a smoother operation, bring energy savings and permit an optimal efficiency e.g. allowing “meet-and-pass” operation whenever possible;
- For Urban and Suburban applications, Driverless (GoA3) and Unattended (GoA4) types of operation will allow for high performance for lines carrying intensive inner Suburban and cross-city services having the full advantage of ETCS (interconnections, train types diversity, interoperability, etc).

ATO over ETCS (up to GoA3/4) will completely change the way future Railway Lines are operated. Without imposing heavy investment to create additional infrastructure, it will:

- improve the services and the customer perception of quality by improving the punctuality and by increasing the transportation capacity in order to face the growing demand in public transport over the coming decades;
- Reduce the operation costs by saving energy and reducing staff;
- Enhance interoperability by producing “ATO over ETCS” interoperable requirements that will be used to modify the current ETCS TSI.

More precisely:

- Punctuality: journey times less variable and closer to timetables;
- Operational headway: less variability in actual Journey time permits the Infrastructure Operator to foresee fewer “reserve time” in the theoretical timetables. This leads to a lower operational headway and will increase the line capacity;
- Mean journey times: less variability in actual Journey time permits the operator to reduce the Journey Times foreseen in the theoretical timetable;
- Energy consumption: the trains are driven according to optimum Speed Profiles that minimises the energy consumption;
- Staff costs: Driverless and Unattended operations allow for reduction of the required operation staff, thus contributing to enhance Railway Transport Productivity.

ATO (up to GoA4) will have a genuine influence on the following:

- Environmental impact (by the reduction of energy consumption).
- Public transport attractiveness (by the reduction of operating costs, Public Authorities will have the possibility to invest in public transport to offer better).
- Safety in Public Transport (higher Grade of Automation globally enhances the safety of the operation).

- The quality of service (shorter mean journey times which are more predictable enhance the punctuality and the quality of service. This will lead to increase of passengers using public transport).

In order to be realistic, the evolution towards “unattended operation” (GoA4) must be implemented incrementally. It will start with a “quick win” solution based on “Semi-Automated” operation (GoA2). This first step will already permit:

- to increase operation performances reducing the operational headway up to 30%;
- to reduce operation cost saving energy consumption by at least 15%;
- To enhance the punctuality and to reduce the mean journey time.

The second step will lead to driverless (GoA3) and unattended operation (GoA4). This second step will permit to reduce operation cost related to staff and to enhance the operation reliability.

# 5 Objective / Aim

5.1.1.1.1 The aim of this document is to specify ATO over ETCS up to GoA4. It includes the final target (which is GoA4), an intermediate step with a train attendant (GoA3), the migration from TSI 2022 (GoA1 or GoA2) and the degraded modes which may lead to lower Grades of Automation.

5.1.1.1.2 This System Requirements Specification (SRS) starts with a system overview in chapter 6 where the logical architecture of the system is presented and with general principles in chapter 7.

5.1.1.1.3 The operational contexts of the system are described in chapter 8.

5.1.1.1.4 The system actors and their functions are described in chapter 9.

5.1.1.1.5 The logical components and their functions are described in chapter 10.

5.1.1.1.6 The actor and system functions are described in chapter 11 with their inputs, outputs and allocation to relevant actor or logical component. Each system function is at least covered by one use case of chapter 12.

5.1.1.1.7 The operational needs are captured via use cases in chapter 12. The system behaviour is described for each use case with the support of sequence diagrams showing the exchanges between relevant actors and logical components functions.

5.1.1.1.8 The data exchanged through the logical interfaces of GoA34 logical components are described in chapter 13.

5.1.1.1.9 The functions of chapter 11 were first identified through a bottom-up approach based on the capture of the functions performed today by the driver and train preparation staff. Most of these functions, at least the driver’s ones, will have to be performed automatically in GoA4. These functions were consolidated through a top-down approach based on the use cases of chapter 12 and regular meetings hold with the operators in a continuous improvement process.

# 6 System overview

The target system is an interoperable ATO over ETCS system covering the different grades of automation defined in chapter 4. The current document is for GoA34, an evolution for the future autonomous trains based on the GoA2 functions specified in TSI 2022 and the new functions required for GoA34.

The figure below shows a larger scope with the logical architecture of a complete railway system not limited to ATO. It brings the following advantages:

- high level context useful for the modelling of Use Cases i.e. a better understanding of the user needs.
- flexibility in modelling which is especially useful for a new system development where several iterations are necessary before to freeze the logical architecture and its functional allocation.
- sharing of a common system view between various stakeholders (same actors, same logical components).

The actors are represented in light blue, they are external to the logical system and will be described in chapter 9 with their associated functions or responsibilities.

The logical system is made of logical components with logical interfaces (FIS level). Each logical component will be described in chapter 10 with its allocated functions and logical interfaces. The GoA34 components are highlighted in yellow while the other logical components are represented in dark blue. The upper part of the diagram is dedicated to the trackside logical components (Train Control, Route Control, DMT, IPM-ISM, Traffic Management, Train Management, ATO-AT) while the lower part is dedicated to onboard logical components (Train Protection, DMO, SCV, Localization, ORD, IPM-OB, PER, ATO-AV). The existing communication channels between onboard and trackside component are SS-026 for ETCS, SS-126 for ATO and C48 between TCMS and Train Management. The new communication channel C19 between IPM-OB and IPM-ISM is for reporting incidents. The new communication channel C34 between DMT and DMO is foreseen for updating the digital map information (SS-126 is used today for segment profile information).

The logical components identified in the logical architecture permit interchangeability or interoperability. They must be allocated to physical components in a physical architecture with interfaces defined at FFFIS level. Different physical architectures are possible by grouping several logical components on the same physical component. The only constraint is that a logical component cannot be split into different physical components for keeping interchangeability.

This specification focuses on GoA34 components and their interfaces. Information related to other components (functions or interfaces) are only given for a better understanding of the complete system behavior. Logical components present in the logical architecture but not analyzed in this specification will have a label «outside the scope of GoA34» in their description.

The GoA34 logical components will be described in chapter 10, they are summarized below:

- ATO-AV and ATO-AT are evolutions of GoA2 components (SIL0).
- IPM-OB substitutes driver and train attendant responsibilities for reacting in case of incident (SIL to be defined).
- Perception is a set of on-board modules sensing the Physical Railway Environment in place of the driver (SIL to be defined).

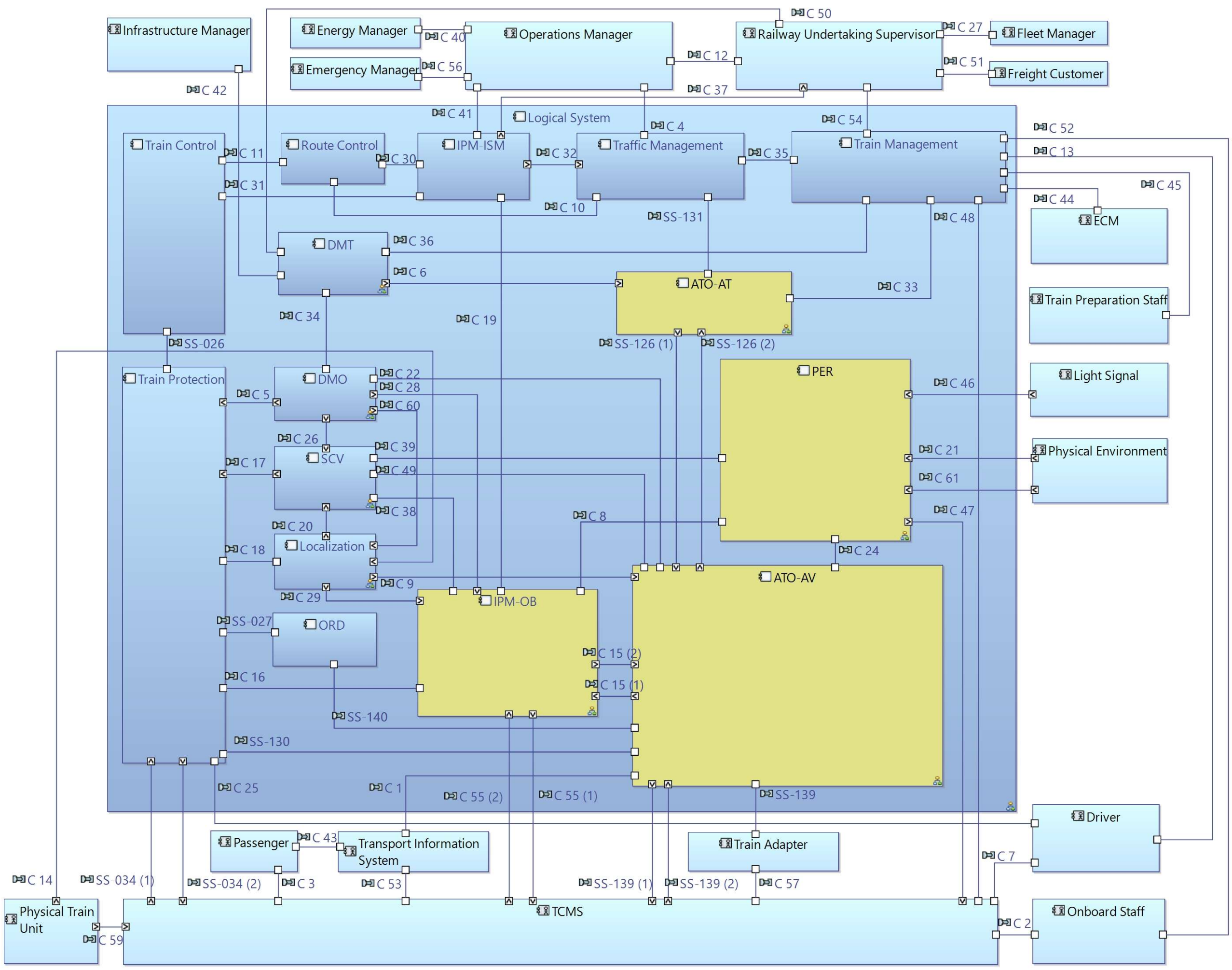



**Figure 6.1 – Logical Architecture**

# 7 General principles

## 7.1 Train Unit and Consist

7.1.1.1.1 The following terms will be used in the following: Vehicle (single item of rolling-stock), Consist (independent item of rolling-stock, comprising one or more mechanically connected Vehicles, whose composition cannot be changed) and Train Unit (logical entity comprising one or more mechanically coupled Consists).

## 7.2 Journey Profile

7.2.1.1.1 Journey Profile (JP) is a concept developed in GoA2 and described in subset-126. Each JP details the journey as passing through a sequence of Segment Profiles (SPs), including mainly timing information and temporary infrastructure information.

7.2.1.1.2 For automatic driving in GoA34, it is necessary to introduce new information to perform automatically specific tasks currently performed by the driver and staff in GoA2 (train awakening, coupling, …). This information will be presented in next Mission Profile chapter dedicated to Railway Undertaking (RU) needs.

## 7.3 Mission Profile

7.3.1.1.1 A detailed timetable is the result of interactions between Infrastructure Manager (IM) defining the commercial paths on available infrastructure and Railway Undertaking (RU) managing the planned runs with available rolling-stock. The timetable is normally known in advance and distributed to driver and train preparation staff for the current day of operation.

7.3.1.1.2 Traffic fluidity is based on a consistent information between RU and IM. IM will send a Journey Profile to a train only if its characteristics are suitable for operation. TSI TAF&TAP defines the exchanges between RU and IM.

7.3.1.1.3 The SNCF example below shows a passenger train made of two Consists, A052 and A053. A053 is the leading unit for the first journey #8510 between 09:00 and 14:35. The Train Unit is then parked until 18:08 for the next journey #8655. A052 is the leading unit for this second journey between 18:08 and 22:19. At 20:20, the Train Unit is split and A052 continues alone while A053 is routed to another destination with the journey #8759.

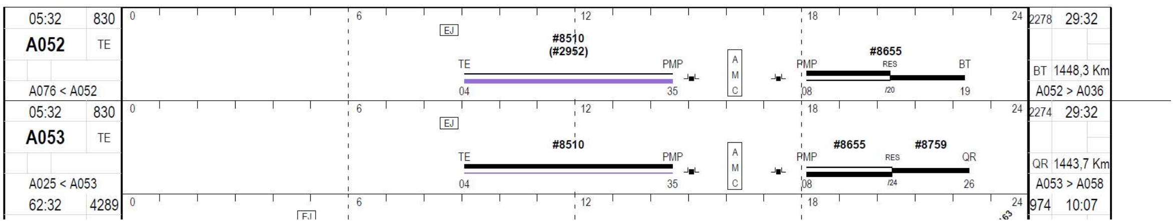


**Figure 7.1 – Mission example (SNCF)**

7.3.1.1.4 The #8510, #8655 and #8759 journeys correspond to valid JPs with a defined departure time, a defined arrival time and an End of Journey. They represent the IM view and the Segments Profiles associated to these journeys can be extracted from an infrastructure database.

7.3.1.1.5 In case a train is no more available for the planned journey, the fleet manager will arrange another train. The journey will remain identical with the same train operational number but will be performed with another GoA34 train prepared and supervised by RU.

7.3.1.1.6 The Mission Profile (MP) gives the list of Journey Profile ID(s) agreed with IM(s) and defines the tasks to be performed on the Train Unit during the timeslots not dedicated to a journey.

7.3.1.1.7 The mission information gives the RU view of each Consist:

- List of planned runs with associated infrastructure servers
- Specific scheduled or unscheduled operation (see below)
- Manual remote driving seen as an operational mode (details to be clarified)
- Specific train preparation tasks including manual tasks
- Several JPs in a consist may be interesting to anticipate some tests and to prepare operation in reverse direction to minimize turnaround time (with ATO to ATO communication to prevent some dynamic effect).

7.3.1.1.8 The specific scheduled or unscheduled operations include all station operations to be done before or after journey by RU, most with human interaction (it can impact JP if train departure is delayed):

- Catering, cleaning (door access): the train must remain at standstill
- Release door time for commercial operation
- Determine state of the train before and after the journey (Retention of service, shutdown, energy saving…)
- Remote or local maintenance procedures
- Coupling and uncoupling freight wagons: small sequences with human interaction
- Services like sand refuelling, water refuelling or fluids refuelling for self-propelling trains.

7.3.1.1.9 When a technical service implies a local movement, it can be scheduled with a modern TMS (JP to go to a washing yard for example) or unscheduled with a simple TMS (simplified JP without arrival time to go from a location to another location without timetable). It is also possible to operate without JP in case of handover between a modern TMS and a local TMS after checking-out of the train.

7.3.1.1.10 The mission characteristics must be defined for each consist. They are listed below with italic characters when optional:

- Identification number
- Date of the mission
- Beginning time of the mission
- Ending time of the mission (to be confirmed)
- Consist number (for check)
- List of Journey Profiles numbers with for each JP:

- ATO-AT address
- Foreseen train composition (single, double, length and weight for cargo or coach, …)
- Place of the consist within the train (leading or not)
- Train mode (functional or hauled vehicle, with passenger service or empty, with wagons or without wagons)
- GoA1/GoA2/GoA3/GoA4/remote driving
- State of the train before and after the journey (start-up time / shutdown time, retention of service, energy saving…)
- *Time to release door before departure*
- *Unscheduled operation before and after JP with services like sand refuelling, water refuelling or fluids refuelling for self-propelling trains with local ATO-AT address*
- *Coupling/decoupling in depot yard unscheduled with local ATO-AT address*
- *Unscheduled movement to first station with local ATO-AT address*
- *Coupling or uncoupling cargo wagon with local ATO-AT address or on-site function*
- *For catering and cleaning, door release time, time window, energy mode*
- *Tasks, if not performed automatically by TCMS, as a set of predefined remote operations done between JPs:*
  - *Heating/cooling time before departure*
  - *Brake test*
  - *ATP test*
  - *ORD data collection*

7.3.1.1.11 Update of GoA2 JP after TSI 2022 will include new information such as:

- GoA1/GoA2/GoA3/GoA4/remote driving
- Commercial state (with or without passenger access)
- Group or PMR at a stopping location
- Power limitations
- Coupling/uncoupling, back to maintenance at a stopping location
- Change of orientation
- (to be completed).

## 7.4 Perception and reaction

### 7.4.1 Overview

7.4.1.1.1 An essential feature of GoA34 is to monitor the train environment and react in case of any anomaly like a driver does today.

7.4.1.1.2 Perception in GoA34 relies on sensors that must emulate or improve the driver's perception, not only the sense of sight but everything that can contribute to the safety of operations. Performance requirements should be challenging in the context of a R&D project, especially with test tracks that offer a good opportunity to measure the effectiveness of a sensor in Railway environment.

7.4.1.1.3 Perception of the external environment implies to detect and recognize static or dynamic objects of different types that can affect operation (fallen tree on the track, level crossing incident…). Classes of object and track zones are defined in the following related chapters.

7.4.1.1.4 Perception of the physical train unit (abnormal vibrations, fire…) and its interior in the case of passenger trains are closely linked to TCMS functionalities and rolling stock design. New passenger trains integrate already several networks to manage various vehicle subsystems, remote maintenance or passenger entertainment. Additional perception sensors could be considered as a normal evolution to a smart train.

7.4.1.1.5 A driver manages all this information and reacts in case of incident. Even if a driver is error prone, the driver's ability to detect and react to a danger is very high. An intelligent module replacing the driver must thus be able to act quickly on the emergency brake when an incident impacts the safety. Other reactions are also possible depending on the situation (horn, speed reduction…). A list of possible reactions must be associated to the various incidents.

### 7.4.2 Zones

7.4.2.1.1 Zones are defined in the Digital Map and are used among other things to determine the criticality of an object present in a given zone.

7.4.2.1.2 Track Zone corresponds to an envelope surroundings the tracks, not smaller than the clearance gauge of the track. Its height corresponds to the Overhead Contact Line.

7.4.2.1.3 Near Track Zone is directly adjacent to Track Zone, its dimension is generally defined according to the speed limit of the track. The current speed of a Train Unit below the speed limit of the track can reduce the width of this zone giving way to the Protection Zone.

7.4.2.1.4 Protection Zone is the zone under the responsibility of IM where only authorized staff is permitted. In the case of high-speed lines, this zone is delimited with fences. In the case of protected level crossings, this zone is delimited with the level crossing barriers.

7.4.2.1.5 Environment Zone is a zone outside Protection zone but within the field of view of perception. Objects detected in this zone do not represent an immediate danger for the train, but they must be tracked, especially in the case of dynamic objects.

7.4.2.1.6 Working Zone is a specific part of the Track Zone and Near Track Zone which is closed for maintenance as the presence of workers and equipment is expected.

7.4.2.1.7 Overhead Line Equipment Zone is the envelope surrounding all Overhead Line Equipment systems.

7.4.2.1.8 Level Crossing Zone is a crossing area which is formed by the intersection of the Track Zone with a crossing road or path at the same level. Moving objects are expected in this area until the level crossing is protected. For unprotected level crossings, the Environment Zone must be considered because a vehicle in approach in this zone could become an obstacle.

7.4.2.1.9 The different zones are illustrated in the figure below.

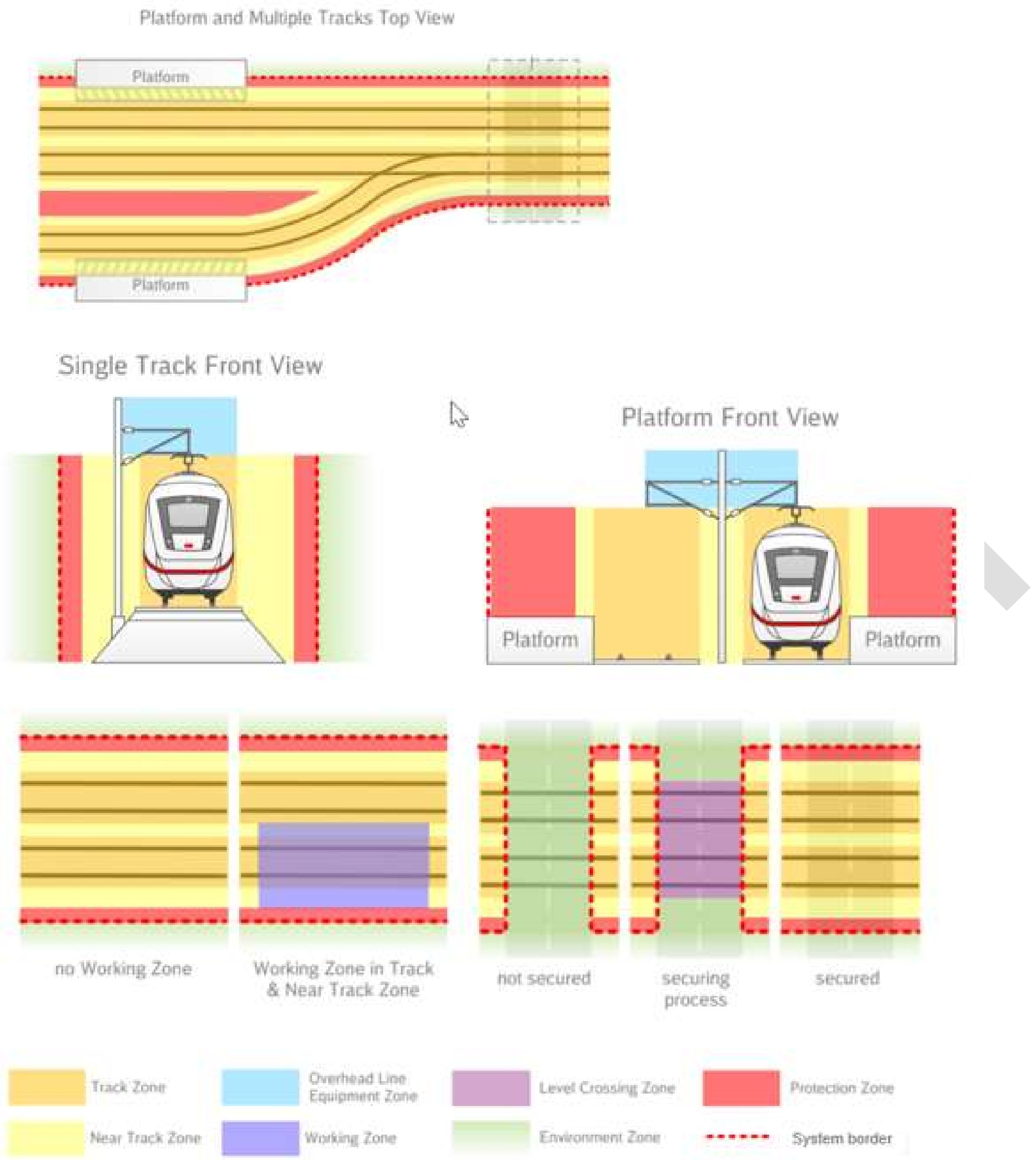



**Figure 7.2 – Trackside observation zones**

### 7.4.3 Objects

7.4.3.1.1 An exhaustive list of objects is not realistic however an unidentified static or dynamic object of significant size must be detected if it can present a danger.

7.4.3.1.2 Well known objects described in the Digital Map will not be considered like obstacles, but they can be used to report an incident (broken level crossing barrier…).

7.4.3.1.3 The table below categorizes the objects in 10 different classes with examples.

| Code | Class | Object |
|---|---|---|
| HUMN | Human | Authorised person, human being |
| LANI | Large Animal | Deer |
| SANI | Small Animal | Sheep |
| ROVE | Road Vehicle | Car, lorry |
| VECO | Vehicle / Consist | Rolling stock |
| INFR | Infrastructure | Buffer stop, equipment room, catenary mast, environmental barriers, level crossing barriers, landmarks… |
| USTO | Unidentified Static Object | Rock, flooding, landslide, various objects… |
| UMOO | Unidentified Moving Object | Falling tree, object falling from a bridge, avalanche… |
| RVEG | Regular Vegetation | Vegetation outside Protection Zone |
| IVEG | Irregular Vegetation | Vegetation inside Protection Zone (fallen tree) |

**Table 7.1 – Object classes**

### 7.4.4 Reactions

7.4.4.1.1 The possible reactions identified at this stage are listed in the table below.

| Reaction | Executed by |
|---|---|
| Obstacle Movement Authority | ETCS-OB |
| Unconditional Emergency Stop | ETCS-OB |

| | |
|---|---|
| Full Service Brake | ATO-AV |
| Service Brake to slow down | ATO-AV |
| Service Brake to stop in a safe point | ATO-AV |
| Sound the horn | ETCS-OB |
| Lower pantograph | ETCS-OB |
| Notify trackside | IPM-OB |
| Inform passengers | TIS |
| Stop diesel engine | ATO-AV (to be confirmed) |
| Flash with lights (optional) | ATO-AV (to be confirmed) |
| Move back (optional) | ATO-AV (ETCS OBU in RV mode) |
| No reaction | IPM-OB |

**Table 7.2 – Possible reactions**

### 7.4.5 Architecture

7.4.5.1.1 In the logical architecture (see Figure 6.1), it is expected that IPM will be safety related and without important modifications while PER will be technology dependent and versatile. The type of sensor, the number of sensors or the diversity of sensors are not defined at system level but should be part of PER development.

7.4.5.1.2 The boundary between PER (identification) and IPM (analysis and reaction) is not yet frozen. From one side, PER could deliver all detected information with the risk of overloading IPM with false positives (a radar picture shows a lot of echoes for example). From the other side, the knowledge of the track could help to filter irrelevant information within PER with the risk of missing an important information.

7.4.5.1.3 In obstacle detection, the priority is given to the detection of an object on the track, not its identification. The knowledge of train position, digital map and route followed by the train is mandatory to decide if a detected object is an obstacle or not. IPM has this knowledge and can be considered as the brain of GoA34. A similar processing implemented in PER should lead to a complex product not in line with the need of standard sensors from various suppliers (automotive field for example).

7.4.5.1.4 For this reason, interfaces between PER and DM or LZ are currently not considered when focusing on GoA34 needs and obstacle detection. However, the need of pre-filtering in PER is relevant and it is proposed that IPM provides a zone of interest to PER to reduce the PER processing time. In a similar manner, SCV could provide a zone of interest to PER to support the identification of a signal aspect (for fixing the ideas, it seems better to focus on 50 relevant pixels than on the millions of pixels of a full image).

7.4.5.1.5 The zone of interest is safety related and depends on the train position, digital map and route followed by the train. A sequence of 3D points modelling the route between the train and a configurable distance from this train is a solution to concatenate relevant information for PER. The spacing of 3D points will depend on the granularity used to model the track topology with its slope, curve and cant.

7.4.5.1.6 Note: Landmark detection is a function allocated to LZ component, grouping of LZ and GoA34 needs is possible in the physical architecture.

# 8 Operational contexts

## 8.1 Overview

8.1.1.1.1 At trackside level, the following operational contexts must be taken into account:

- GoA0: no ETCS fitment. A national ATP system can be implemented however it is not in the scope of this specification.
- GoA1: fitted with ETCS trackside, no ATO fitment.
- GoA2: fitted with ETCS trackside and ATO-AT supporting GoA2.
- GoA3: fitted with ETCS trackside and ATO-AT supporting GoA3.
- GoA4: fitted with ETCS trackside and ATO-AT supporting GoA4.

8.1.1.1.2 At on-board level, the following operational contexts must be taken into account:

- GoA0: no ETCS fitment. The driver is fully responsible. A national ATP system can be implemented however it is not in the scope of this specification.
- GoA1: equipped with ETCS-OB. The driver is responsible for train driving and obstacle detection.
- GoA2: equipped with ETCS-OB and ATO-AV supporting GoA2. The driver is responsible for obstacle detection and can take responsibility of train driving in case of emergency, on-sight or degraded situations. A Driver Advisory System (DAS) assists manual driving according to subset-125.
- GoA3: equipped with ETCS-OB and ATO-AV supporting GoA3. No driver anymore. A train attendant is managing the degraded situations and possibly the passengers exchange.
- GoA4: equipped with ETCS-OB and ATO-AV supporting GoA4. No driver and no train attendant anymore. Remote operation may be provided to manage irregular situations without the need to send staff to the train.

8.1.1.1.3 In addition, trackside areas must allow operation in the highest available GoA level, as well as any lower GoA levels depending on ATO-AV capabilities. For example, a maintenance train should be able to circulate on a GoA4 area without automatic operation.

8.1.1.1.4 Before a train enters in a new GoA area, a handshaking process between ATO-AV and ATO-AT will be performed to determine the ATO system version (M_ATO_Version). If no major ATO system version is supported by both ATO-AV and ATO-AT, ATO-AT shall answer with a “no compatible” value of the ATO system version to be used and the communication shall be terminated. Such reaction would have an important operational impact in GoA34 because there is no driver to continue without ATO. This must be prevented through a check at planning level to prevent non-usable trains be blocked somewhere on track.

8.1.1.1.5 The following table shows all possible Operational Contexts (OCs) resulting from a train mission through areas equipped with all possible GoA levels. Each line represents a train with cab operating in a given GoA level.

| | | Trackside GoA level | | | | |
|---|---|---|---|---|---|---|
| | | 4 | 3 | 2 | 1 | 0 |
| On-board GoA level (train with cab) | 4 | Unattended (OC1) | | | | |
| | 3 | Attendant (OC2) | Attendant (OC2) | | | |
| | 2 | Driver (OC3) | Driver (OC3) | Driver (OC3) | | |
| | 1 | Driver (OC4) | Driver (OC4) | Driver (OC4) | Driver (OC4) | |
| | 0 | Driver (OC5) | Driver (OC5) | Driver (OC5) | Driver (OC5) | Driver (OC5) |

**Table 8.1 – Operational contexts**

8.1.1.1.6 The table shows that an area equipped with GoA4 can be crossed by GoA4, GoA3, GoA2, GoA1 and GoA0 trains. It gives a constraint on trackside GoA4 that must be able to differentiate GoA2, GoA3 and GoA4 trains when elaborating a mission and to consider all possible trains when monitoring environment.

8.1.1.1.7 The table shows also that a GoA4 train requires a train attendant before to enter in GoA3 and a driver before to enter in a GoA2, GoA1 or GoA0 area. The diagonal of the table shows the progressive transfer of responsibility from the system to attendant or driver for a GoA4 train. Starting point is the fully automated operation with train protection. From GoA4 to GoA3, the presence of on-board staff is required to manage specific situations. From GoA3 to GoA2, the presence of the driver is required, and the system responsibility is reduced to train driving and train protection. From GoA2 to GoA1, the system ensures only the train protection (with DAS option). From GoA1 to GoA0, the system does not ensure anymore the train protection and the driver is fully responsible.

8.1.1.1.8 A GoA4 train has all functionalities to run in GoA4. The train will run in GoA3 in case of degraded situations (fixing a door problem for example) or if the trackside imposes on-board staff in some areas, either systematically or depending of specific events. Static constraints can be a main station for the departure authorization or specific tunnels where evacuation requires the presence of staff for example.

8.1.1.1.9 GoA3 and GoA4 missions should be the same from the TMS point of view. A specific field has simply to be added in the Mission Profile to precise if on-board staff is mandatory or not in some areas (static constraint). TMS shall also have the possibility to inform that a train cannot be operated in GoA4 (dynamic constraint).

8.1.1.1.10 The case of a train without driving cab (pure GoA34 train) will be considered like a particular case of the previous table in the scenarios. A driving cab is no more necessary, but it is not interoperable and therefore out of scope of this document.

8.1.1.1.11 The operational contexts share almost the same actors except for the driver and on-board staff that are not present in GoA4. These contexts determine the actors defined in chapter 9.

8.1.1.1.12 Note: the operational contexts do not cover all possible contexts of the system. They must be completed by technical contexts and their associated actors for the different phases of the system life cycle (maintenance context for example).

## 8.2 Related scenarios

8.2.1.1.1 The scenarios will be analysed in the chapter 12 dedicated to Use Cases.

8.2.1.1.2 Most of these scenarios are related to a GoA4 train running on a line equipped with GoA4 (OC1).

8.2.1.1.3 The scenarios associated to a GoA4 train running on a line equipped with GoA3 or GoA4 (OC2) are particular cases of the scenarios defined in (OC1) when an action from on-board staff is required. Two specific scenarios are dedicated to the transitions OC1->OC2 and OC2->OC1.

8.2.1.1.4 The scenarios associated to a GoA4 train running on a line equipped with GoA2 (OC3) are particular cases of the scenarios defined in GoA2 specifications. Two specific scenarios are dedicated to the transitions OC1->OC3 and OC3->OC1.

8.2.1.1.5 The scenarios associated to a GoA4 train running on a line equipped with GoA1 (OC4) or GoA0 (OC5) do not involve ATO however they imply two specific scenarios dedicated to the transitions OC1->OC4/OC5 and OC4/OC5->OC1.

## 8.3 Related ATO modes

8.3.1.1.1 The GoA4 ATO-AV has several driving modes to deal with the different operational contexts and several technical modes to enter or leave operation.

8.3.1.1.2 The State Machine (STM) below presents these modes with the related transitions for a full automatic train equipped with a driving cab. The modes to be considered are the elementary modes, they are grouped in contextual modes for a better understanding.

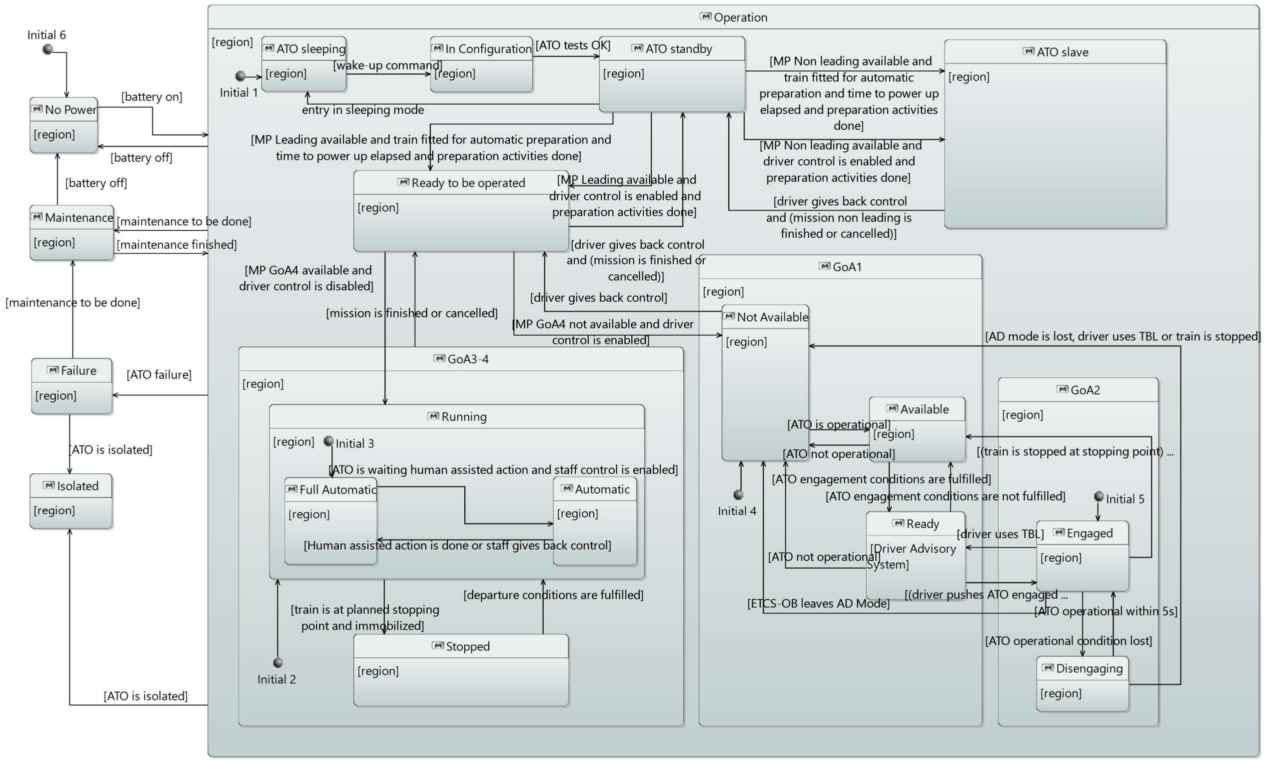



**Figure 8.1 – STM ATO-AV**

8.3.1.1.3 The No Power mode is the mode where a human intervention is required to wake-up the train (failure of permanent battery).

8.3.1.1.4 The Maintenance mode is dedicated to maintenance activities (tests, download…).

8.3.1.1.5 The Failure mode is the mode where ATO operation is no more possible. Depending on the failure, ATO must be isolated or a remote control is possible (it is assumed that remote control is an external system not part of ATO). Maintenance is necessary to recover the full operational capability.

8.3.1.1.6 The Isolation mode is external to ATO system, a switch permits to remove the train control from ATO.

8.3.1.1.7 The ATO sleeping mode is a saving energy mode where most of ATO functionalities are deactivated and minimum communication capabilities are kept. It is assumed that a permanent battery permits to start in this mode in most of the cases.

8.3.1.1.8 The In Configuration mode is the mode where ATO performs tests to check its ability to operate. It includes self-tests and tests of its perception systems. This mode can be activated by RU, driver or train preparation staff. Depending on the test results, ATO switches to ATO standby mode or Failure mode.

8.3.1.1.9 The ATO standby mode is the mode where ATO is active and ready to power-up the train. The Mission Profile (MP) defines the time when the train needs to be powered and defines if ATO is driving the leading unit or a slave unit. If the train is fitted for automatic preparation, all train preparation activities are performed automatically. If the train is not able to perform automatically all preparation activities, the driver is required to switch on some systems in a leading unit or in a slave unit or entering ETCS data when required.

8.3.1.1.10 When all train preparation activities are finished, ATO will switch from ATO standby mode to ATO slave mode in the case of a slave unit or to Ready to be operated mode in the case of a leading unit.

8.3.1.1.11 The ATO slave mode is the mode where ATO is the slave of a master ATO. The master ATO drives the different TCMS of the various units. The master ATO and the slave ATO(s) manage the various sensors distributed along the train however the physical architecture is not yet frozen to decide if one ATO must manage everything or if a sharing is preferable.

8.3.1.1.12 The Ready to be operated mode is the mode where the train is ready to be operated. In this mode, ATO waits for a Mission Profile to enter in GoA34 context or actions from the driver to enter in GoA1 context or GoA2 context via GoA1 context. This driver was identified during ATO standby mode through the insertion of a key or similar mechanism permitting to unlock the Traction Braking Lever. This mode can be entered with a train at standstill (start of mission) or while train is running (transition on the fly between GoA2 and GoA4 during a long tunnel crossing for example).

8.3.1.1.13 GoA3 and GoA4 contexts are grouped because they are both related to the movement of an automatic train. The mission is the same from the trackside point of view but the train can be configured in GoA3 or GoA4 depending on implementation.

8.3.1.1.14 A GoA4 mission consists in a succession of stops (Stopped mode) and runs (Full Automatic mode). If the train is configured GoA3, some actions will be required from the on-board staff in Automatic mode. In some stations, a support from the dispatcher can be required to authorize the train departure. ATO enters in Ready to be operated mode when the GoA3 or GoA4 mission is finished or cancelled.

8.3.1.1.15 The Running mode includes Full Automatic mode and Automatic mode. This mode is entered from Ready to be operated mode when a GoA4 Mission profile is available and leads to Stopped mode if the train is immobilized at a planned stopped location. In case ATO operational conditions are lost, service brake must be applied until stop or recovery of operational conditions (equivalent of disengaging state in GoA2).

8.3.1.1.16 The Stopped mode is related to an operational stop for passengers or coupling where GoA4 train is at standstill and ready to start when the departure conditions are fulfilled (automatically in GoA4 and with an action from train attendant in GoA3). The Stopped mode is required for door management and dwell time supervision with associated transitions. For coupling, the Stopped mode is used for the first train to be coupled, it gives the feedback necessary to authorize the second train to couple.

8.3.1.1.17 Note: with modern TCMS, holding brake is controlled by TCMS at standstill, not ATO (ATO must apply traction to remove holding brake). If not a modern TCMS, ATO can send/remove the holding brake command but it is a deviation from current SS-125 specification).

8.3.1.1.18 GoA1 and GoA2 contexts group the modes of GoA2 specifications. The Not Available mode means that ATO-AV does not have a mission, it is working in background and the train is only supervised by ATP and the driver.

8.3.1.1.19 There is no GoA0 context because ATO is always operational unless ATO fails or is isolated. These cases are covered by failure and isolation modes like for GoA1, GoA2, GoA3 and GoA4.

8.3.1.1.20 The transition between GoA4 and GoA3 can be done while running and leads from Full Automatic mode to Automatic mode. The system checks that train attendant is ready to take the hand (specific key for example) before to authorize transition. If the train attendant does not confirm the transition after a configurable time, the train shall be stopped. This transition is described in the scenario “Transition of a GoA4 train from GoA4 to GoA3 inside a GoA34 area”.

8.3.1.1.21 The transition between GoA3 and GoA4 can be done while running and leads from Automatic mode to Full Automatic mode. The system checks that train is in an area where full automatic driving is allowed before to authorize transition and must know that train attendant has left the cab. This transition is described in the scenario “Transition of a GoA4 train from GoA3 to GoA4 inside a GoA34 area”.

8.3.1.1.22 The transition between GoA3/GoA4 and GoA1 is done via the Ready to be operated mode.

8.3.1.1.23 The transition between GoA1 and GoA3/GoA4 is done via the Ready to be operated mode.

# 9 Description of actors

## 9.1 Driver

| |
|---|
| The Driver represents a person from Railway Undertaking that drives a train directly or remotely when GoA34 operation is no more possible (lines not equipped with GoA34 or degraded modes from GoA34). This entity includes the Local Driver when the train is equipped with a driving desk and the Remote Driver when the train is remote controlled. |

### 9.1.1 Allocated Functions

- Manage doors (driver)
- Manage journey
- Perform shunting
- Manage freight operation
- Stop precisely in station
- Drive train
- Manage reporting
- Detect obstacles
- Drive train remotely
- Check-out/Check-in vehicle

## 9.2 ECM

| |
|---|
| The Entity in Charge of Maintenance (ECM) means an entity in charge of maintenance of a vehicle and registered as such in the National Vehicle Register (NVR). This entity includes the Vehicle Maintenance Manager and the Vehicle Maintenance Worker. |

### 9.2.1 Allocated Functions

- Check-out/Check-in vehicle
- Schedule routine maintenance

## 9.3 Emergency Manager

| |
|---|
| The Emergency Manager carries-out non-automated emergency functions which require human actions. This person is part of the Infrastructure Management entity.<br><br>He can also act remotely as a remote driver via C48 (interface to be standardised). |

### 9.3.1 Allocated Functions

- Organize recovery

## 9.4 Energy Manager

| |
|---|
| The Energy Manager manages the electrical power distribution along the track and catenaries.<br><br>This manager is part of the Infrastructure Management entity. |

### 9.4.1 Allocated Functions

- Manage power demand
- Manage energy demand

## 9.5 Fleet Manager

| |
|---|
| The Fleet Manager or Keeper means the person or entity that, being the owner of a vehicle or having the right to use it, exploits the vehicle as a means of transport and is registered as such in the National Vehicle Register referred to in Article 33 of the Interoperability directive 2008/57. |

### 9.5.1 Allocated Functions

- Attribute trainset to mission

## 9.6 Freight Customer

| |
|---|
| The Freight Customer is the person in charge of the purchasing of the transport contract. He provides the freight characteristics (weight, type...) and the schedule for the RU Supervisor. |

### 9.6.1 Allocated Functions

- Communicate freight parameters

## 9.7 Infrastructure Manager

| |
|---|
| The Infrastructure Manager (IM) provides the rail infrastructure, manages all relevant infrastructure data and maintains the infrastructure.<br><br>This person is part of the Infrastructure Management entity. |

### 9.7.1 Allocated Functions

- Manage infrastructure database

## 9.8 Light Signal

| |
|---|
| The Light Signal is an optical indicator that transmits information to train drivers. |

### 9.8.1 Allocated Functions

- Display signal aspect

## 9.9 Onboard Staff

| |
|---|
| The Onboard Staff represents the persons from Railway Undertaking that can be present on a train. This entity includes the Train Attendant for GoA3 operation, the Catering Worker and the Diagnostician. |

### 9.9.1 Allocated Functions

- Manage doors (train attendant)
- Request assisted driving

## 9.10 Operations Manager

| |
|---|
| The Operations Manager represents a person responsible for the railway operation of the System in a given geographic area. This person is part of the Infrastructure Management entity.<br><br>The Operations Manager supervises the normal operation performed automatically by Traffic Management and manages specific actions that cannot be executed automatically. |

### 9.10.1 Allocated Functions

- Dispatch orders
- Request protection against high voltage switch on
- Ensure the monitoring of running trains
- Solve conflicts
- Manage temporary speed restriction
- Authorize SR movements
- Take initial actions in case of emergencies
- Manage track adhesion
- Set routes
- Request catenary power shutdown
- Manage possession

## 9.11 Passenger

| |
|---|
| The Passenger represents the persons travelling on-board passenger trains and embarking or disembarking at stations. |

### 9.11.1 Allocated Functions

- Command doors opening
- Trigger alarm signal

- Speak and listen

## 9.12 Physical Environment

| |
|---|
| Physical Environment (PE) represents the physical environment around infrastructure assets and Vehicles as well as inside Vehicles. It consists of any entities being part of the railway system or external to it that might have an influence on railway operation. |

### 9.12.1 Allocated Functions

- Trigger events

## 9.13 Physical Train Unit

| |
|---|
| The Physical Train Unit conveys passengers or freight to destination. |

### 9.13.1 Allocated Functions

- Move along the track
- Be identified like an autonomous train

## 9.14 Railway Undertaking Supervisor

| |
|---|
| The Railway Undertaking Supervisor represents a person from Railway Undertaking requesting the System to perform Train Unit Runs in order to fulfill transport demand. |

### 9.14.1 Allocated Functions

- Define mission
- Communicate with passengers
- Request video stream
- Supervise trains
- Manage vehicle database

## 9.15 TCMS

| |
|---|
| The Train Control Management System represents the systems installed on a train with which an interaction is necessary in order to perform automatic railway operation (brakes, traction...). TCMS functions are extracted from EN 15380-4. |

### 9.15.1 Allocated Functions

- H.E.D Manage energy supply for traction
- G.C.F.C.C Provide Brake Command for Holding Braking
- G.C.C Acquire brake demand (direct brake)
- H.E.D Manage energy supply for auxiliaries
- G.C.B Configure brake system

- D.B.B Release external doors
- F.B.E Protect collection devices and catenary
- F.F.D Generate mechanical energy for traction
- G.C.F.C.B Provide Brake Command for Parking Braking
- H.E.E.G Manage climatisation
- F.C.H Provide low voltage DC supply
- H.C.B Inaugurate train network
- D.B.C Open external doors
- F.H Provide chemical energy for traction
- H.E.E Manage windscreen cleaning
- G.D.B Command sanding
- G.C.F.F Acquire realised braking effort
- D.B.D Close external doors
- F.B.B Sense catenary voltage
- H.B.E Provide train radio information
- H.E.J Manage exterior lighting
- G.C.F.C.E Provide Brake Command for Emergency Braking
- G.C.G Apply and release braking forces
- G.C.H Detect sliding
- H.E.J Manage acoustic warning system
- G.B Provide acceleration
- D.B.M Signal external door status change/open/close
- D.B.P Reduce the gap between vehicle and platform
- G.C.F.C.E-W.A Provide Test (Emergency Brake)
- E.B.B Prepare the coupling
- E.B.B Open cover
- H.D Manage train modes
- E.B.C Manage uncoupling
- H.E.B Manage cab control
- H.E.H.F Manage isolation of devices
- D.C Provide access by internal door
- J.B.K Provide a suspension diagnostic
- K.D.C.B Alarming mechanism to the ground (shunting circuit compensator state)
- F.C.H.B Provide charging
- H.E.E.F Manage interior lighting
- B.E.D Manage signalling of fire
- B.E.E Manage/Provide fire extinguishment
- F.E Provide fluid energy for auxiliaries
- C.E.F. Provide possibility to open windows
- J.B.H Monitor wheelset bearing status
- C.F.D Manage emergency alarm from passengers
- D.B Provide external access
- D.B.E Manage door system upon obstacle
- E.B.C Close cover
- H.E.H.G Provide remote control

- H.H Assist troubleshooting
- H.H-W.E Provide Maintenance
- G.C.F.C.D Provide Brake Command for Service Braking
- J.B.C Provide derailment information
- H.E.H Manage control of the train parameters
- C.F.F. Provide passenger emergency intercommunication
- H.E.E Manage surveillance system
- K.D.C Provide train to ground communication
- J.B.E Remove obstacle on the track
- H.E.E Manage appropriate and safe conditions

## 9.16 Train Adapter

The Train Adapter is a set of configurable functions necessary to interface with an existing train not equipped with a modern TCMS. These functions are project specific and not covered in this specification.

Note: Train Adapter/system interfaces are identical to TCMS/system interfaces. The related functions interface with «virtual» TCMS functions (TCMS is not existing) to provide the same generic interface with the system.

## 9.17 Train Preparation Staff

The Train preparation staff represents the persons from Railway Undertaking that intervene on a train when it is at standstill. This entity includes the Shunting Yard Worker, the Wagon Load Worker and the Clean Worker.

### 9.17.1 Allocated Functions

- Couple locomotive
- Request brake test
- Check brake pressure
- Check conformity of brake data
- Request compression
- Request coupling
- Request locomotive wake-up
- Request train hold
- Uncouple locomotive
- Determine brake test to trigger
- Request brake release
- Elaborate brake data
- Release scotches
- Close brake pipe cock
- Set train unit

- Open main pipe on last wagon
- Realize cold weather operations
- Open brake pipe cock
- Set scotches if necessary
- Check train immobilization
- Check shoes apply on wheel
- Check shoes not apply on wheel
- Set/remove local protection for high voltage
- Check-out/Check-in vehicle

## 9.18 Transport Information System

| |
|---|
| The Transport Information System represents a system that aggregates and stores information about System and/or the current operational situation. It provides this information to different actors, including public transport service, through visual, voice or other media. |

### 9.18.1 Allocated Functions

- Give visual and audible indication to passengers (in train)

# 10 Description of Logical Components

## 10.1 ATO-AT

| |
|---|
| This trackside logical component supervises all GoA34 trains.<br><br>SIL: 0<br><br>Note: this component is called ATO-TS in GoA2 specifications. |

### 10.1.1 Allocated Functions

- Receive status report
- Determine/verify and transmit JP data
- Transmit coupling authorization
- Transmit updated infrastructure database
- Receive status of safety related equipment
- Transmit TPS orders
- Determine/verify and transmit MP data
- Transmit incidents to TIS
- Receive anomalies in task or mission execution
- Manage ATO connections

### 10.1.2 List of interfaces

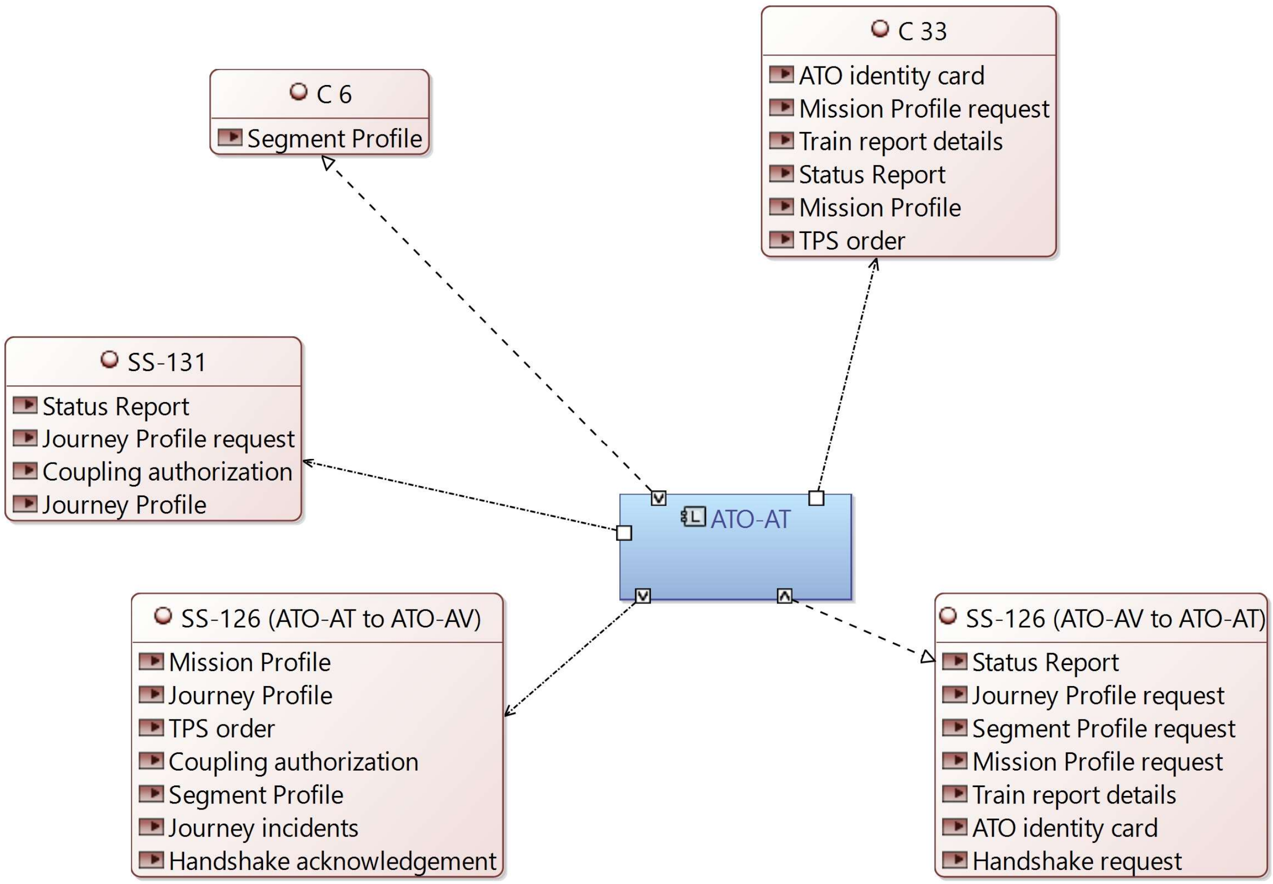



**Figure 10.1 – Detailed interfaces**

### 10.1.3 SS-126 (1)

| With | Functional Exchange | Exchange Item |
|---|---|---|
| ATO-AV | infra database version number | Segment Profile |
| ATO-AV | infra database update | Segment Profile |
| ATO-AV | coupling authorization | Coupling authorization |
| ATO-AV | Journey Profile | Journey Profile |
| ATO-AV | grip/ground adhesion problem | Status Report |
| ATO-AV | stopping anomalies | Status Report |
| ATO-AV | request compression | TPS order |

| | | |
|---|---|---|
| ATO-AV | request train wake-up | TPS order |
| ATO-AV | brake release OK | TPS order |
| ATO-AV | uncoupling OK | TPS order |
| ATO-AV | electro-pneumatic brake test OK | TPS order |
| ATO-AV | release brake request | TPS order |
| ATO-AV | apply brake request | TPS order |
| ATO-AV | coupling OK | TPS order |
| ATO-AV | request coupling | TPS order |
| ATO-AV | mission modification | Mission Profile |
| ATO-AV | mission | Mission Profile |
| ATO-AV | msg_ information_about_incident | Journey incidents |
| ATO-AV | handshake acknowledgement | Handshake acknowledgement |

#### 10.1.4 SS-126 (2)

| With | Functional Exchange | Exchange Item |
|---|---|---|
| ATO-AV | train location + heading + speed | Status Report |
| ATO-AV | train health status | Status Report |
| ATO-AV | train local protection status | Status Report |
| ATO-AV | Journey Profile Request | Journey Profile request |
| ATO-AV | request infra database update | Segment Profile request |
| ATO-AV | request infra database version number | Segment Profile request |
| ATO-AV | new stopping point | Journey Profile request |
| ATO-AV | ATO state | Status Report |

| | | |
|---|---|---|
| ATO-AV | driving anomalies | Status Report |
| ATO-AV | misrouting detected | Status Report |
| ATO-AV | request task addition | Mission Profile request |
| ATO-AV | task delay warning | Mission Profile request |
| ATO-AV | mission modification rejected | Mission Profile request |
| ATO-AV | task rejected | Mission Profile request |
| ATO-AV | EB test time and status | Train report details |
| ATO-AV | ATO identity record | ATO identity card |
| ATO-AV | light alarm signal status (specific) | Train report details |
| ATO-AV | track to train radio equipment status (specific) | Train report details |
| ATO-AV | infra database version number | Train report details |
| ATO-AV | ORD memory capacity | Train report details |
| ATO-AV | on-going task number | Mission Profile request |
| ATO-AV | STM status | Train report details |
| ATO-AV | request for extended dwell time | Status Report |
| ATO-AV | handshake request | Handshake request |

### 10.1.5 SS-131

| With | Functional Exchange | Exchange Item |
|---|---|---|
| Traffic Management | Status Report | Status Report |
| Traffic Management | Journey Profile | Journey Profile |
| Traffic Management | request for extended dwell time | Status Report |

| | | |
|---|---|---|
| Traffic Management | coupling authorization | Coupling authorization |
| Traffic Management | Journey Profile Request | Journey Profile request |

### 10.1.6 C 6

| With | Functional Exchange | Exchange Item |
|---|---|---|
| DMT | database update | Segment Profile |
| DMT | database update | Segment Profile |

### 10.1.7 C 33

| With | Functional Exchange | Exchange Item |
|---|---|---|
| Train Management | ATO identity record | ATO identity card |
| Train Management | request compression | TPS order |
| Train Management | request train wake-up | TPS order |
| Train Management | brake release OK | TPS order |
| Train Management | uncoupling OK | TPS order |
| Train Management | electro-pneumatic brake test OK | TPS order |
| Train Management | release brake request | TPS order |
| Train Management | apply brake request | TPS order |
| Train Management | coupling OK | TPS order |

| | | |
|---|---|---|
| Train Management | request coupling | TPS order |
| Train Management | request task addition | Mission Profile request |
| Train Management | task delay warning | Mission Profile request |
| Train Management | on-going task number | Mission Profile request |
| Train Management | mission modification rejected | Mission Profile request |
| Train Management | task rejected | Mission Profile request |
| Train Management | mission modification | Mission Profile |
| Train Management | mission | Mission Profile |
| Train Management | msg_ information_about_incident | Journey incidents |
| Train Management | status of safety related equipment | Train report details |
| Train Management | Status Report | Status Report |

## 10.2 ATO-AV

This logical component is in the train and drives a train automatically.

SIL: 0

Note: this component is called ATO-OB in GoA2 specifications.

### 10.2.1 Allocated Functions

- Start door closing sequence
- Transmit periodically train location

- Determine traction and deceleration capabilities
- Check ad hoc brake release
- Determine dynamic brake test time and location
- Isolate/engage ATO outputs
- Stop exactly at the intended location
- Define brake sequence to apply
- Supervise service brake efficiency during operation
- Supervise train wake-up
- Collect status of safety related equipment
- Calculate expected braking effort
- Select running direction
- Provide Train Protection parameters
- Determine movement direction
- Detect that final stopping point has been reached
- Authorize the release of the doors
- Detect misrouting
- Respect JP Timing Points
- Provide juridical data
- Determine track on which the train is engaged and direction
- Determine stopping point relative to the platform
- Optimize the consumption
- Manage mission
- Provide unit position in the multiple unit
- Supervise manual coupling sequence
- Supervise manual uncoupling sequence
- Calculate all possible itineraries
- Give current protection state
- Define if ATO is master or slave
- Control initial traction effort
- Transmit information to TIS
- Start coupling
- Calculate expected traction effort
- Regulate traction and brake in distance
- Update data of movements within allocated train path
- Calculate speed curve with incidents
- Command headlights/dipped headlights
- Determine maximum authorised speed
- Supervise the departure of the train
- Supervise ATO connection and wake-up
- Deactivate vigilance
- Monitor health status of the train
- Adapt dynamic train behavior
- Check and update the infrastructure data base (if necessary)
- Regulate traction and braking effort
- Start splitting

- Control coupler relaxing effort
- Maintain train immobilization
- Supervise driving desk
- Determine ATO state
- Maintain train physically immobilized
- Determine next stopping point or rescue point
- Suppress sanding
- Give current time
- Transmit driving anomalies

### 10.2.2 List of interfaces

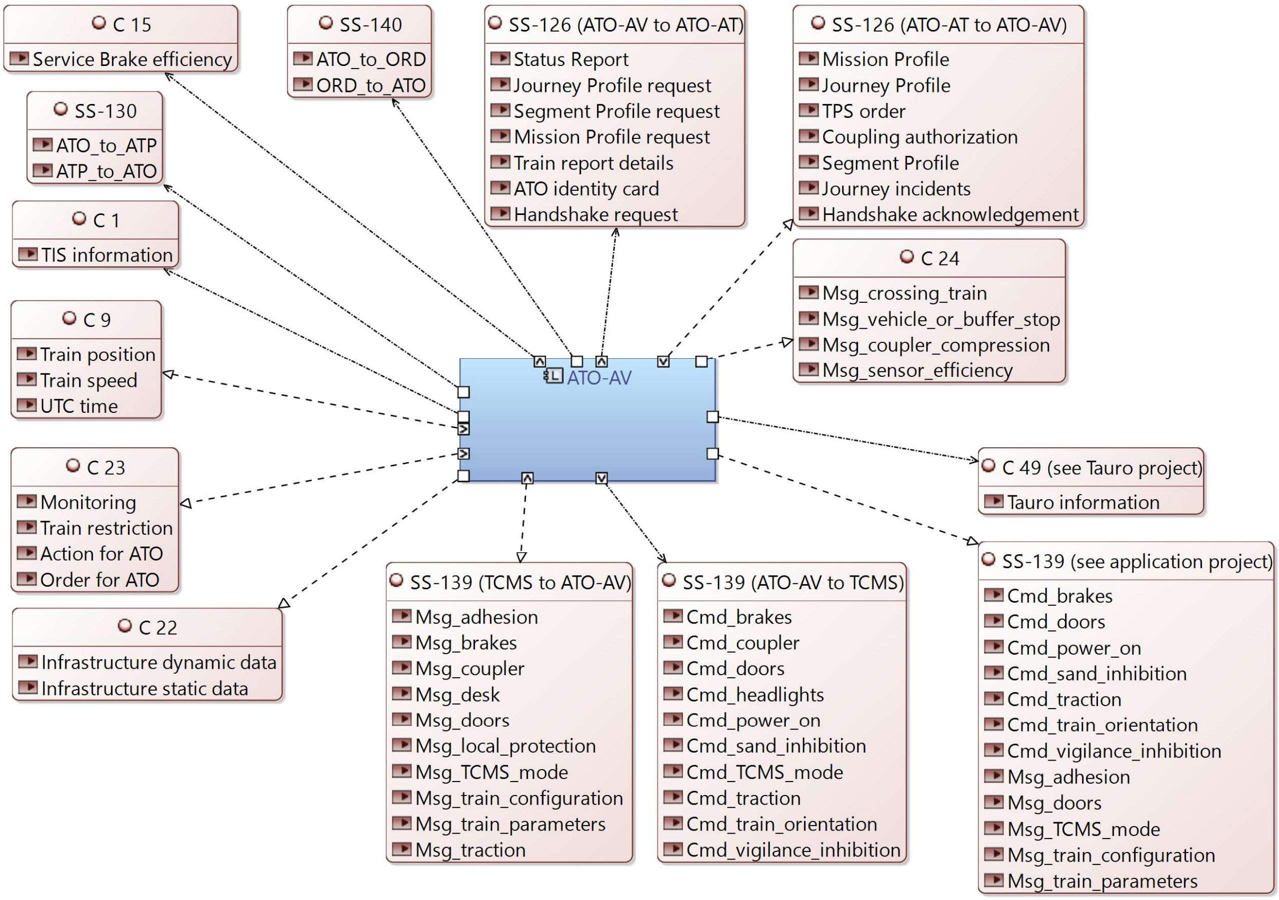



**Figure 10.2 – Detailed interfaces**

### 10.2.3 SS-139 (1)

| With | Functional Exchange | Exchange Item |
|---|---|---|
| TCMS | door close request | Cmd_doors |
| TCMS | door open request | Cmd_doors |

| | | |
|---|---|---|
| TCMS | door enable request | Cmd_doors |
| TCMS | vigilance inhibition | Cmd_vigilance_inhibition |
| TCMS | train orientation | Cmd_train_orientation |
| TCMS | cmd headlights/dipped headlights | Cmd_headlights |
| TCMS | cmd open close trapdoor | Cmd_coupler |
| TCMS | cmd_heat_coupler | Cmd_coupler |
| TCMS | cmd service retention mode | Cmd_TCMS_mode |
| TCMS | cmd splitting | Cmd_coupler |
| TCMS | cmd power on train | Cmd_power_on |
| TCMS | cmd driving mode | Cmd_TCMS_mode |
| TCMS | cmd accurate traction force | Cmd_traction |
| TCMS | brake pressure | Cmd_brakes |
| TCMS | cmd brake for accurate stop | Cmd_brakes |
| TCMS | holding brake release | Cmd_brakes |
| TCMS | holding brake request | Cmd_brakes |
| TCMS | cmd traction force | Cmd_traction |
| TCMS | request brake test sequence after coupling | Cmd_brakes |
| TCMS | request brake test sequence without coupling | Cmd_brakes |
| TCMS | cmd direct brake release | Cmd_brakes |
| TCMS | cmd brake during itinerary | Cmd_brakes |
| TCMS | cmd traction force | Cmd_traction |
| TCMS | cmd direct brake application | Cmd_brakes |

| | | |
|---|---|---|
| TCMS | cmd brake pipe = 0 bar | Cmd_brakes |
| TCMS | request brake release sequence | Cmd_brakes |
| TCMS | braking regime | Cmd_brakes |
| TCMS | cmd brake pipe = reference pressure | Cmd_brakes |
| TCMS | cmd traction off | Cmd_traction |
| TCMS | cmd brake pressure = 0,5 bar | Cmd_brakes |
| TCMS | sand suppression command | Cmd_sand_inhibition |
| TCMS | cmd direct brake application | Cmd_brakes |
| TCMS | cmd direct brake release | Cmd_brakes |
| TCMS | cmd shutdown mode | Cmd_TCMS_mode |
| TCMS | door opening parameters | Cmd_doors |
| TCMS | cmd battery protection mode | Cmd_TCMS_mode |

### 10.2.4 SS-139 (2)

| With | Functional Exchange | Exchange Item |
|---|---|---|
| TCMS | doors status = released | Msg_doors |
| TCMS | door status = open | Msg_doors |
| TCMS | doors status = closed and locked | Msg_doors |
| TCMS | train configuration | Msg_train_configuration |
| TCMS | splitting done | Msg_coupler |
| TCMS | TCMS in service retention mode | Msg_TCMS_mode |
| TCMS | TCMS in shutdown mode | Msg_TCMS_mode |
| TCMS | train inauguration | Msg_train_configuration |

| | | |
|---|---|---|
| TCMS | vehicle powered | Msg_TCMS_mode |
| TCMS | grip/ground adhesion problem | Msg_adhesion |
| TCMS | measured traction force | Msg_traction |
| TCMS | measured brake force | Msg_brakes |
| TCMS | local protection status | Msg_local_protection |
| TCMS | holding brake status | Msg_brakes |
| TCMS | measured traction force | Msg_traction |
| TCMS | travelling direction 1 or 2 | Msg_train_configuration |
| TCMS | measured brake force | Msg_brakes |
| TCMS | measured brake force | Msg_brakes |
| TCMS | desk status | Msg_desk |
| TCMS | train length | Msg_train_parameters |
| TCMS | train category | Msg_train_parameters |
| TCMS | train length | Msg_train_parameters |
| TCMS | train length | Msg_train_parameters |
| TCMS | obtained braked weight | Msg_train_parameters |
| TCMS | mass on the rail | Msg_train_parameters |
| TCMS | wagon type - characteristics | Msg_train_parameters |
| TCMS | train composition | Msg_train_parameters |
| TCMS | train composition | Msg_train_parameters |
| TCMS | train parameters | Msg_train_parameters |
| TCMS | train length | Msg_train_parameters |
| TCMS | maximum train speed | Msg_train_parameters |

| | | |
|---|---|---|
| TCMS | braking capacity | Msg_train_parameters |
| TCMS | train composition and brake capacity data | Msg_train_parameters |
| TCMS | TCMS mode | Msg_TCMS_mode |
| TCMS | direct brake applied | Msg_brakes |
| TCMS | measured traction force | Msg_traction |
| TCMS | direct brake applied | Msg_brakes |

### 10.2.5 SS-126 (1)

| With | Functional Exchange | Exchange Item |
|---|---|---|
| ATO-AT | infra database version number | Segment Profile |
| ATO-AT | infra database update | Segment Profile |
| ATO-AT | coupling authorization | Coupling authorization |
| ATO-AT | Journey Profile | Journey Profile |
| ATO-AT | grip/ground adhesion problem | Status Report |
| ATO-AT | stopping anomalies | Status Report |
| ATO-AT | request compression | TPS order |
| ATO-AT | request train wake-up | TPS order |
| ATO-AT | brake release OK | TPS order |
| ATO-AT | uncoupling OK | TPS order |
| ATO-AT | electro-pneumatic brake test OK | TPS order |
| ATO-AT | release brake request | TPS order |
| ATO-AT | apply brake request | TPS order |
| ATO-AT | coupling OK | TPS order |

| | | |
|---|---|---|
| ATO-AT | request coupling | TPS order |
| ATO-AT | mission modification | Mission Profile |
| ATO-AT | mission | Mission Profile |
| ATO-AT | msg_ information_about_incident | Journey incidents |
| ATO-AT | handshake acknowledgement | Handshake acknowledgement |

### 10.2.6 SS-126 (2)

| With | Functional Exchange | Exchange Item |
|---|---|---|
| ATO-AT | train location + heading + speed | Status Report |
| ATO-AT | train health status | Status Report |
| ATO-AT | train local protection status | Status Report |
| ATO-AT | Journey Profile Request | Journey Profile request |
| ATO-AT | request infra database update | Segment Profile request |
| ATO-AT | request infra database version number | Segment Profile request |
| ATO-AT | new stopping point | Journey Profile request |
| ATO-AT | ATO state | Status Report |
| ATO-AT | driving anomalies | Status Report |
| ATO-AT | misrouting detected | Status Report |
| ATO-AT | request task addition | Mission Profile request |
| ATO-AT | task delay warning | Mission Profile request |
| ATO-AT | mission modification rejected | Mission Profile request |
| ATO-AT | task rejected | Mission Profile request |
| ATO-AT | EB test time and status | Train report details |

| | | |
|---|---|---|
| ATO-AT | ATO identity record | ATO identity card |
| ATO-AT | light alarm signal status (specific) | Train report details |
| ATO-AT | track to train radio equipment status (specific) | Train report details |
| ATO-AT | infra database version number | Train report details |
| ATO-AT | ORD memory capacity | Train report details |
| ATO-AT | on-going task number | Mission Profile request |
| ATO-AT | STM status | Train report details |
| ATO-AT | request for extended dwell time | Status Report |
| ATO-AT | handshake request | Handshake request |

### 10.2.7 C 1

| With | Functional Exchange | Exchange Item |
|---|---|---|
| Transport Information System | cmd_do_not_open_the_door | TIS information |
| Transport Information System | cmd_please_remove_obstacle_from_door | TIS information |
| Transport Information System | cmd_some_doors_will_remain_locked | TIS information |
| Transport Information System | journey information | TIS information |
| Transport Information System | end of passenger service | TIS information |

| | | |
|---|---|---|
| Transport Information System | train departure time | TIS information |
| Transport Information System | msg_ information_about_incident | TIS information |
| Transport Information System | coupling of train warning | TIS information |
| Transport Information System | door opening parameters | TIS information |

### 10.2.8 C 9

| With | Functional Exchange | Exchange Item |
|---|---|---|
| Localization | location + trainset heading | Train position |
| Localization | train speed = 0 | Train speed |
| Localization | location + trainset heading | Train position |
| Localization | current speed | Train speed |
| Localization | location + trainset heading | Train position |
| Localization | train speed = 0 | Train speed |
| Localization | location + trainset heading | Train position |
| Localization | location + trainset heading | Train position |
| Localization | current speed | Train speed |
| Localization | location + trainset heading | Train position |
| Localization | UTC time | UTC time |
| Localization | location + trainset heading | Train position |
| Localization | train speed = standstill | Train speed |

| | | |
|---|---|---|
| Localization | location + trainset heading | Train position |
| Localization | location + trainset heading | Train position |
| Localization | location + trainset heading | Train position |
| Localization | current speed | Train speed |
| Localization | current speed | Train speed |
| Localization | location + trainset heading | Train position |
| Localization | location + trainset heading | Train position |
| Localization | location + trainset heading | Train position |
| Localization | location+ trainset heading | Train position |

### 10.2.9 SS-130

| With | Functional Exchange | Exchange Item |
|---|---|---|
| Train Protection | Q_AD_MODE_REQUEST | ATO_to_ATP |
| Train Protection | ATO engage button | ATP_to_ATO |
| Train Protection | ATP parameters validated | ATP_to_ATO |
| Train Protection | ATP parameters | ATO_to_ATP |
| Train Protection | STM status | ATP_to_ATO |
| Train Protection | EB test time and status | ATP_to_ATO |
| Train Protection | ATO disengage button | ATP_to_ATO |
| Train Protection | TBL control | ATP_to_ATO |

| | | |
|---|---|---|
| Train Protection | ETCS_ATO_Dynamic | ATP_to_ATO |
| Train Protection | BG list | ATP_to_ATO |
| Train Protection | MA | ATP_to_ATO |
| Train Protection | NID_ENGINE | ATP_to_ATO |
| Train Protection | NID_OPERATIONAL | ATP_to_ATO |

### 10.2.10 C 15 (1)

| With | Functional Exchange | Exchange Item |
|---|---|---|
| IPM-OB | msg_service_brake_not efficient | Service Brake efficiency |
| IPM-OB | msg_service_brake_not efficient | Service Brake efficiency |

### 10.2.11 C 15 (2)

| With | Functional Exchange | Exchange Item |
|---|---|---|
| IPM-OB | surroundings OK | Monitoring |
| IPM-OB | air suspension isolated | Train restriction |
| IPM-OB | axle restriction | Train restriction |
| IPM-OB | pantograph restriction | Train restriction |
| IPM-OB | full service brake | Action for ATO |
| IPM-OB | request coasting | Train restriction |
| IPM-OB | service brake to slow down | Action for ATO |
| IPM-OB | catenary voltage | Train restriction |

| | | |
|---|---|---|
| IPM-OB | authorization to close the doors | Order for ATO |
| IPM-OB | authorization to proceed | Order for ATO |
| IPM-OB | cmd_physical_immobilization | Order for ATO |
| IPM-OB | cmd_remove_physical_immobilization | Order for ATO |
| IPM-OB | absence of passengers in the train | Monitoring |
| IPM-OB | msg to remove obstacle | Action for ATO |
| IPM-OB | door closure forced | Action for ATO |
| IPM-OB | door restriction | Train restriction |
| IPM-OB | degraded braking capacity | Train restriction |
| IPM-OB | fluid level for non-electric engines | Train restriction |
| IPM-OB | train consist failure | Train restriction |
| IPM-OB | degraded traction capacity | Train restriction |
| IPM-OB | start prohibited | Order for ATO |
| IPM-OB | horn disturbed | Train restriction |
| IPM-OB | service brake to rescue point | Action for ATO |
| IPM-OB | main battery no more charging | Train restriction |
| IPM-OB | cmd battery protection mode | Action for ATO |
| IPM-OB | potential trackside train detection problem | Train restriction |

#### 10.2.12 C 24

| With | Functional Exchange | Exchange Item |
|---|---|---|
| PER | train or vehicle in opposite direction | Msg_crossing_train |

| | | |
|---|---|---|
| PER | trainset / wagons parked on the track | Msg_vehicle_or_buffer_stop |
| PER | coupler compression | Msg_coupler_compression |
| PER | sensor efficiency distance | Msg_sensor_efficiency |
| PER | trainset / wagons parked on the track | Msg_vehicle_or_buffer_stop |

### 10.2.13 SS-140

| With | Functional Exchange | Exchange Item |
|---|---|---|
| ORD | initiate ORD exchange | ATO_to_ORD |
| ORD | memory capacity | ORD_to_ATO |
| ORD | juridical data | ATO_to_ORD |

### 10.2.14 C 22

| With | Functional Exchange | Exchange Item |
|---|---|---|
| DMO | dynamic brake test location | Infrastructure dynamic data |
| DMO | platform characteristics | Infrastructure static data |
| DMO | platform characteristics | Infrastructure static data |
| DMO | track parameters | Infrastructure static data |
| DMO | track parameters | Infrastructure static data |
| DMO | next stopping points or rescue points | Infrastructure static data |
| DMO | infrastructure database | Infrastructure static data |
| DMO | track parameters | Infrastructure static data |
| DMO | track parameters | Infrastructure static data |
| DMO | track parameters | Infrastructure static data |

## 10.3 DMO

| |
|---|
| The Digital Map Onboard (DMO) component is in the train and stores infrastructure data on the train.<br><br>SIL: to be defined<br><br>This component is outside the scope of GoA34. |

### 10.3.1 Allocated Functions

- Extract infrastructure database information

## 10.4 DMT

| |
|---|
| The Digital Map Trackside (DMT) component manages infrastructure and vehicle digital information.<br><br>SIL: to be defined<br><br>This component is outside the scope of GoA34. |

### 10.4.1 Allocated Functions

- Provide infrastructure database
- Provide vehicle database

## 10.5 IPM-ISM

| |
|---|
| The Incident and Prevention Management - Incident Solving Manager (IPM-ISM) component predicts the geographical, temporal and resource-related impact of Events on scheduled railway operation. Solving processes are aligned and prioritised. Specified routines are created to resolve Non-Regular Situations with a minimal impact on railway operation. Planned routines are executed and assisting entities coordinated. An Incident is monitored and managed during his whole lifecycle from the first recognition to the dissolution.<br><br>SIL: to be defined<br><br>This component is outside the scope of GoA34. |

### 10.5.1 Allocated Functions

- Manage trackside incidents
- Transmit supervision orders
- Manage train incidents

## 10.6 IPM-OB

This logical component is in the train and should substitute driver and train attendant responsibilites for reacting in case of incident (Incident and Prevention Management - Onboard). It manages safe reflexive reactions, computed reactions and safety procedures in cooperation with IPM-ISM.

SIL: to be defined

### 10.6.1 Allocated Functions

- Check if the surroundings (except signalling) oppose the departure
- Define driving action depending on incident
- Monitor fire alarm
- Monitor axle box temperature
- Monitor EB distance to Danger Point
- Monitor alarm signal
- Monitor derailment
- Monitor train unit failures
- Alarm all trains locally
- Monitor shunting circuit compensator default
- Monitor TIS status
- Monitor pantograph
- Monitor loss of voltage or low voltage
- Monitor suspension status
- Monitor train interior
- Monitor couplers
- Transmit anomalies of the surroundings
- Receive supervision orders
- Transmit train incident report
- Map and monitor object
- Monitor weather conditions
- Monitor doors incidents
- Monitor battery protection mode

### 10.6.2 List of interfaces

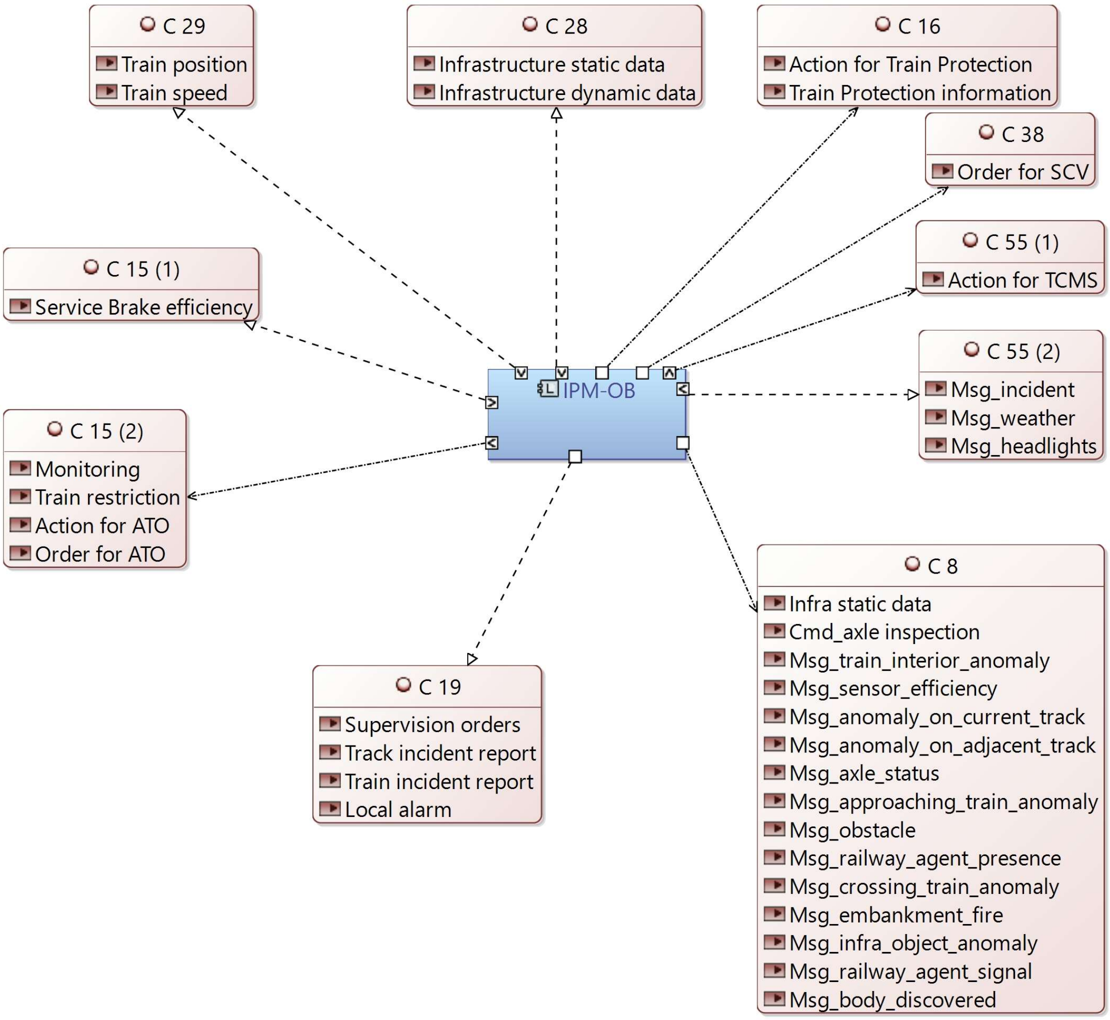



**Figure 10.3 – Detailed interfaces**

### 10.6.3 C 8

| With | Functional Exchange | Exchange Item |
|---|---|---|
| PER | presence of a maintenance area | |
| PER | adjacent tracks anomalies | Msg_anomaly_on_adjacent_track |
| PER | point failure identified | |
| PER | area of interest | Infra static data |

| | | |
|---|---|---|
| PER | broken or buckled track | Msg_anomaly_on_adjacent_track |
| PER | rear light missing | Msg_crossing_train_anomaly |
| PER | distance to obstacle + type | Msg_obstacle |
| PER | other crossing train anomalies | Msg_crossing_train_anomaly |
| PER | broken or buckled track | Msg_anomaly_on_current_track |
| PER | broken or buckled track | Msg_anomaly_on_adjacent_track |
| PER | detected obstacle + type | Msg_obstacle |
| PER | damage to catenary identified | |
| PER | catenary / track anomaly on the route | Msg_anomaly_on_current_track |
| PER | trainset / wagons parked on the track | Msg_vehicle_or_buffer_stop |
| PER | level crossing damage | Msg_infra_object_anomaly |
| PER | sparks on a roof | Msg_crossing_train_anomaly |
| PER | unusual movements | Msg_train_anomaly |
| PER | msg_flooding | Msg_anomaly_on_current_track |
| PER | axle inspection | Cmd_axle inspection |
| PER | msg_flooding (adjacent track) | Msg_anomaly_on_adjacent_track |
| PER | broken or buckled track | Msg_anomaly_on_current_track |
| PER | axle status | Msg_axle_status |
| PER | level crossing damage | Msg_infra_object_anomaly |

| | | |
|---|---|---|
| PER | unexpected passenger | Msg_train_interior_anomaly |
| PER | rear light missing | Msg_approaching_train_anomaly |
| PER | railway agent signal | Msg_railway_agent_signal |
| PER | msg_live_stock_wandering | Msg_anomaly_on_current_track |
| PER | sensor efficiency distance | Msg_sensor_efficiency |
| PER | fire description | Msg_embankment_fire |
| PER | msg_anomalies_on_catenary | Msg_anomaly_on_current_track |
| PER | authorized persons on/near the track | Msg_railway_agent_presence |
| PER | front light missing | Msg_approaching_train_anomaly |
| PER | msg_anomalies_of_adjacent_catenary | Msg_anomaly_on_adjacent_track |
| PER | msg_flooding | Msg_anomaly_on_current_track |
| PER | level crossing to run with caution speed | |
| PER | front light missing | Msg_crossing_train_anomaly |
| PER | inappropriate behavior | Msg_train_interior_anomaly |
| PER | suspicious luggage | Msg_train_interior_anomaly |
| PER | uncontrolled train detected | Msg_crossing_train_anomaly |
| PER | unusual movements | Msg_train_anomaly |
| PER | anomalies in rear of the train | Msg_train_anomaly |
| PER | anomalies on train sides | Msg_train_anomaly |

| | | |
|---|---|---|
| PER | area of interest | Infra static data |
| PER | msg_body discovered | Msg_anomaly_on_adjacent_track |
| PER | injury to a person | Msg_body_discovered |
| PER | msg_body discovered | Msg_anomaly_on_current_track |
| PER | injury to a person | Msg_body_discovered |
| PER | authorized persons on/near the track | Msg_railway_agent_presence |

### 10.6.4 C 15 (1)

| With | Functional Exchange | Exchange Item |
|---|---|---|
| ATO-AV | msg_service_brake_not efficient | Service Brake efficiency |
| ATO-AV | msg_service_brake_not efficient | Service Brake efficiency |

### 10.6.5 C 38

| With | Functional Exchange | Exchange Item |
|---|---|---|
| SCV | caution speed on a given distance | Order for SCV |
| SCV | On sight speed until next MA (line side signal) | Order for SCV |
| SCV | cmd_speed_restriction | Order for SCV |

### 10.6.6 C 28

| With | Functional Exchange | Exchange Item |
|---|---|---|
| DMO | infrastructure objects | Infrastructure static data |
| DMO | point failure identified | Infrastructure dynamic data |
| DMO | damage to catenary identified | Infrastructure dynamic data |

| | | |
|---|---|---|
| DMO | flooding identified | Infrastructure dynamic data |
| DMO | level crossing to run with caution speed | Infrastructure dynamic data |
| DMO | broken or buckled rail identified | Infrastructure dynamic data |

### 10.6.7 C 29

| With | Functional Exchange | Exchange Item |
|---|---|---|
| Localization | location + trainset heading | Train position |
| Localization | current speed | Train speed |
| Localization | location + trainset heading | Train position |

### 10.6.8 C 16

| With | Functional Exchange | Exchange Item |
|---|---|---|
| Train Protection | emergency stop | Action for Train Protection |
| Train Protection | pantograph drop request | Action for Train Protection |
| Train Protection | cmd emergency pantograph drop | Action for Train Protection |
| Train Protection | horn request | Action for Train Protection |
| Train Protection | obstacle MA | Action for Train Protection |
| Train Protection | next danger point | Train Protection information |

### 10.6.9 C 55 (1)

| With | Functional Exchange | Exchange Item |
|---|---|---|
| TCMS | cmd_ventilation_without_energy | Action for TCMS |

### 10.6.10 C 55 (2)

| With | Functional Exchange | Exchange Item |
|---|---|---|
| TCMS | HVAC failure | Msg_incident |
| TCMS | suspension status | Msg_incident |
| TCMS | hot box | Msg_incident |
| TCMS | loss in fluid energy | Msg_incident |
| TCMS | EB brake failure | Msg_incident |
| TCMS | alarm signal | Msg_incident |
| TCMS | TIS problem | Msg_incident |
| TCMS | fire on board | Msg_incident |
| TCMS | current gap detected | Msg_incident |
| TCMS | pantograph problem | Msg_incident |
| TCMS | high_voltage_anomaly | Msg_incident |
| TCMS | bogie instability detected | Msg_incident |
| TCMS | potential trackside train detection problem | Msg_incident |
| TCMS | sudden decrease of pressure | Msg_incident |
| TCMS | interior light failure | Msg_incident |
| TCMS | weather information | Msg_weather |
| TCMS | door failure | Msg_incident |
| TCMS | loss of headlights | Msg_headlights |
| TCMS | obstacle | Msg_incident |
| TCMS | horn disturbed | Msg_incident |
| TCMS | msg_main_battery_power_level | Msg_incident |

| | | |
|---|---|---|
| TCMS | broken window | Msg_incident |
| TCMS | loss of headlights | |
| TCMS | train consist failure | |
| TCMS | degraded traction capacity | Msg_incident |
| TCMS | degraded braking capacity | Msg_incident |
| TCMS | fluid level for non-electric engines | Msg_incident |

### 10.6.11 C 19

| With | Functional Exchange | Exchange Item |
|---|---|---|
| IPM-ISM | track anomaly | Track incident report |
| IPM-ISM | surroundings anomalies | Track incident report |
| IPM-ISM | train anomaly | Train incident report |
| IPM-ISM | authorization to close the doors | Supervision orders |
| IPM-ISM | battery protection request | Supervision orders |
| IPM-ISM | cmd_speed_restriction | Supervision orders |
| IPM-ISM | cmd caution speed on a given distance | Supervision orders |
| IPM-ISM | authorization to proceed | Supervision orders |
| IPM-ISM | override_process | Supervision orders |
| IPM-ISM | pantograph drop request | Supervision orders |
| IPM-ISM | cmd_physical_immobilization | Supervision orders |
| IPM-ISM | cmd_remove_physical_immobilization | Supervision orders |
| IPM-ISM | local alarm needed | Local alarm |
| IPM-ISM | start prohibited | Supervision orders |

### 10.6.12 C 15 (2)

| With | Functional Exchange | Exchange Item |
|---|---|---|
| ATO-AV | surroundings OK | Monitoring |
| ATO-AV | air suspension isolated | Train restriction |
| ATO-AV | axle restriction | Train restriction |
| ATO-AV | pantograph restriction | Train restriction |
| ATO-AV | full service brake | Action for ATO |
| ATO-AV | request coasting | Train restriction |
| ATO-AV | service brake to slow down | Action for ATO |
| ATO-AV | catenary voltage | Train restriction |
| ATO-AV | authorization to close the doors | Order for ATO |
| ATO-AV | authorization to proceed | Order for ATO |
| ATO-AV | cmd_physical_immobilization | Order for ATO |
| ATO-AV | cmd_remove_physical_immobilization | Order for ATO |
| ATO-AV | absence of passengers in the train | Monitoring |
| ATO-AV | msg to remove obstacle | Action for ATO |
| ATO-AV | door closure forced | Action for ATO |
| ATO-AV | door restriction | Train restriction |
| ATO-AV | degraded braking capacity | Train restriction |
| ATO-AV | fluid level for non-electric engines | Train restriction |
| ATO-AV | train consist failure | Train restriction |
| ATO-AV | degraded traction capacity | Train restriction |

| | | |
|---|---|---|
| ATO-AV | start prohibited | Order for ATO |
| ATO-AV | horn disturbed | Train restriction |
| ATO-AV | service brake to rescue point | Action for ATO |
| ATO-AV | main battery no more charging | Train restriction |
| ATO-AV | cmd battery protection mode | Action for ATO |
| ATO-AV | potential trackside train detection problem | Train restriction |

## 10.7 Localization

The Localization (LZ) component is in the train and provides tachymetry and location information for all train subsystems.

SIL: to be defined

This component is outside the scope of GoA34.

### 10.7.1 Allocated Functions

- Localize vehicle (track/direction/position/heading)
- Measure train speed
- Provide UTC time

## 10.8 ORD

The On-board Recording Device (ORD) component is in the train and records juridical data from ETCS and ATO-AV.

SIL: 0

This component is outside the scope of GoA34.

### 10.8.1 Allocated Functions

- Record juridical data

## 10.9 PER

The Perception (PER) component is in the train and senses the Physical Railway Environment in place of a driver.

SIL: to be defined

### 10.9.1 Allocated Functions

- Identify an obstacle downstream or already encountered
- Measure sensor efficiency distance
- Detect railway agents on or along the tracks
- Measure coupler compression
- Detect sparks on a train roof
- Detect abnormal noises and vibrations on the train
- Monitor condition of current track and catenary
- Monitor conditions of adjacent tracks and catenaries
- Detect person struck by train
- Detect unusual movements
- Detect hand signal or red light flare
- Detect fire or heavy smoke on embankment
- Stream video data
- Detect abnormal passenger behavior
- Detect presence of passengers
- Detect vehicle or buffer stop on the same track
- Detect light failure on a train unit on the same track
- Detect light failure on a crossing train unit
- Detect crossing train
- Detect anomalies on crossing train
- Detect uncontrolled crossing train
- Detect level crossing damage
- Check hot box
- Detect incident on train rear
- Detect incident on train sides

### 10.9.2 List of interfaces

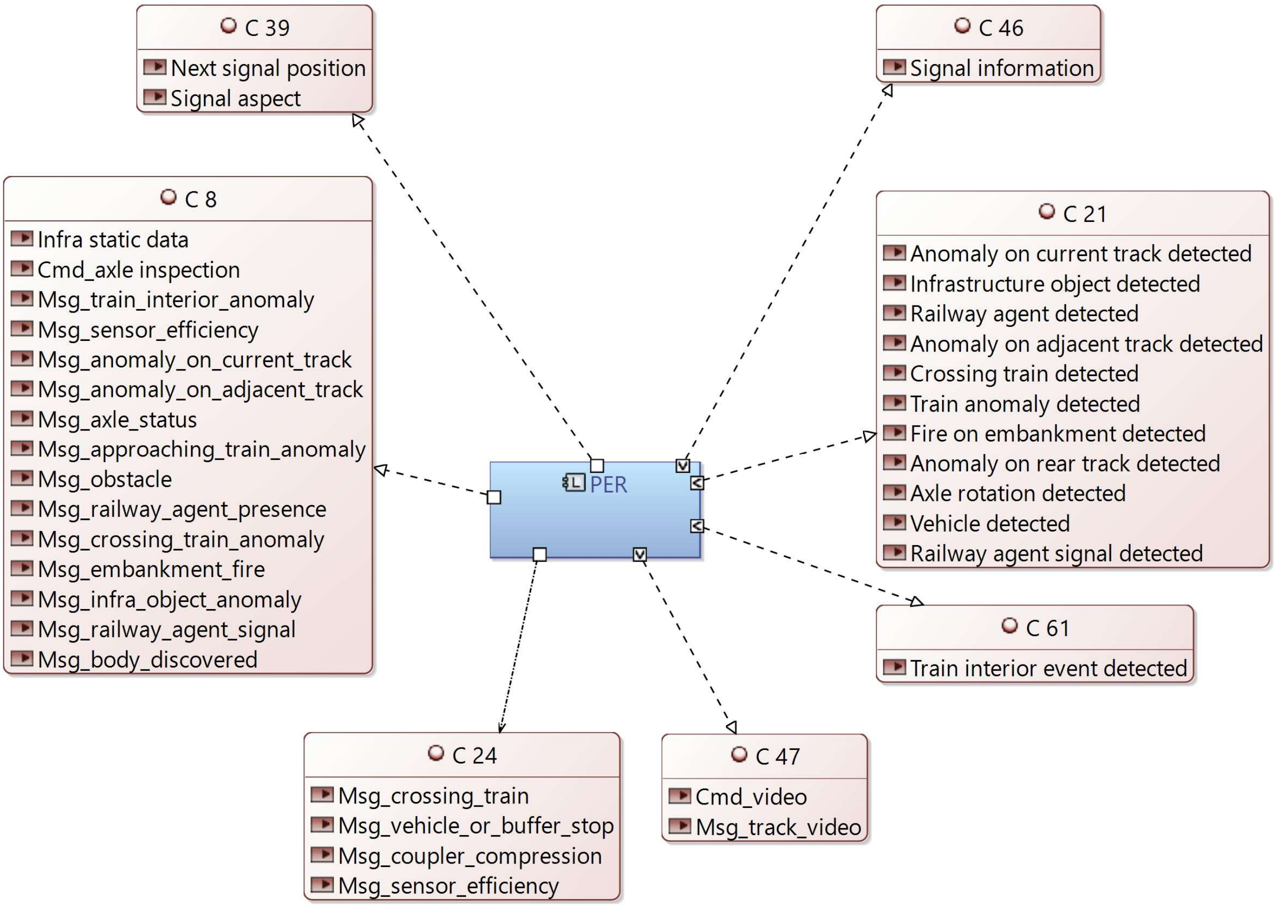



**Figure 10.4 – Detailed interfaces**

### 10.9.3 C 21

| With | Functional Exchange | Exchange Item |
|---|---|---|
| Physical Environment | level crossing damage | Infrastructure object detected |
| Physical Environment | railway agent | Railway agent detected |
| Physical Environment | catenary anomaly (adjacent track) | Anomaly on adjacent track detected |
| Physical Environment | sparks on a roof | Crossing train detected |

| | | |
|---|---|---|
| Physical Environment | flooding (adjacent track) | Anomaly on adjacent track detected |
| Physical Environment | track anomaly | Anomaly on current track detected |
| Physical Environment | track anomaly (adjacent track) | Anomaly on adjacent track detected |
| Physical Environment | live stock wandering | Anomaly on current track detected |
| Physical Environment | body discovered | Anomaly on adjacent track detected |
| Physical Environment | catenary anomaly | Anomaly on current track detected |
| Physical Environment | abnormal noise | Train anomaly detected |
| Physical Environment | flooding | Anomaly on current track detected |
| Physical Environment | body discovered | Anomaly on current track detected |
| Physical Environment | vehicle on track | Vehicle detected |
| Physical Environment | crossing train anomalies | Crossing train detected |
| Physical Environment | external fire | Fire on embankment detected |
| Physical Environment | railway agent signal | Railway agent signal detected |
| Physical Environment | incident caused by the train | Anomaly on rear track detected |
| Physical Environment | axle rotation at low speed | Axle rotation detected |

| | | |
|---|---|---|
| Physical Environment | train body dynamic | Train anomaly detected |
| Physical Environment | uncontrolled train | Crossing train detected |
| Physical Environment | crossing train anomalies | Crossing train detected |
| Physical Environment | crossing train in approach | Crossing train detected |
| Physical Environment | vehicle on track | Vehicle detected |
| Physical Environment | train side anomaly | Train anomaly detected |
| Physical Environment | strucked person | Anomaly on current track detected |

### 10.9.4 C 8

| With | Functional Exchange | Exchange Item |
|---|---|---|
| IPM-OB | presence of a maintenance area | |
| IPM-OB | adjacent tracks anomalies | Msg_anomaly_on_adjacent_track |
| IPM-OB | point failure identified | |
| IPM-OB | area of interest | Infra static data |
| IPM-OB | broken or buckled track | Msg_anomaly_on_adjacent_track |
| IPM-OB | rear light missing | Msg_crossing_train_anomaly |
| IPM-OB | distance to obstacle + type | Msg_obstacle |
| IPM-OB | other crossing train anomalies | Msg_crossing_train_anomaly |
| IPM-OB | broken or buckled track | Msg_anomaly_on_current_track |

| | | |
|---|---|---|
| IPM-OB | broken or buckled track | Msg_anomaly_on_adjacent_track |
| IPM-OB | detected obstacle + type | Msg_obstacle |
| IPM-OB | damage to catenary identified | |
| IPM-OB | catenary / track anomaly on the route | Msg_anomaly_on_current_track |
| IPM-OB | trainset / wagons parked on the track | Msg_vehicle_or_buffer_stop |
| IPM-OB | level crossing damage | Msg_infra_object_anomaly |
| IPM-OB | sparks on a roof | Msg_crossing_train_anomaly |
| IPM-OB | unusual movements | Msg_train_anomaly |
| IPM-OB | msg_flooding | Msg_anomaly_on_current_track |
| IPM-OB | axle inspection | Cmd_axle inspection |
| IPM-OB | msg_flooding (adjacent track) | Msg_anomaly_on_adjacent_track |
| IPM-OB | broken or buckled track | Msg_anomaly_on_current_track |
| IPM-OB | axle status | Msg_axle_status |
| IPM-OB | level crossing damage | Msg_infra_object_anomaly |
| IPM-OB | unexpected passenger | Msg_train_interior_anomaly |
| IPM-OB | rear light missing | Msg_approaching_train_anomaly |
| IPM-OB | railway agent signal | Msg_railway_agent_signal |
| IPM-OB | msg_live_stock_wandering | Msg_anomaly_on_current_track |
| IPM-OB | sensor efficiency distance | Msg_sensor_efficiency |

| | | |
|---|---|---|
| IPM-OB | fire description | Msg_embankment_fire |
| IPM-OB | msg_anomalies_on_catenary | Msg_anomaly_on_current_trac k |
| IPM-OB | authorized persons on/near the track | Msg_railway_agent_presence |
| IPM-OB | front light missing | Msg_approaching_train_anoma ly |
| IPM-OB | msg_anomalies_of_adjacent_c atenary | Msg_anomaly_on_adjacent_tra ck |
| IPM-OB | msg_flooding | Msg_anomaly_on_current_trac k |
| IPM-OB | level crossing to run with caution speed | |
| IPM-OB | front light missing | Msg_crossing_train_anomaly |
| IPM-OB | inappropriate behavior | Msg_train_interior_anomaly |
| IPM-OB | suspicious luggage | Msg_train_interior_anomaly |
| IPM-OB | uncontrolled train detected | Msg_crossing_train_anomaly |
| IPM-OB | unusual movements | Msg_train_anomaly |
| IPM-OB | anomalies in rear of the train | Msg_train_anomaly |
| IPM-OB | anomalies on train sides | Msg_train_anomaly |
| IPM-OB | area of interest | Infra static data |
| IPM-OB | msg_body discovered | Msg_anomaly_on_adjacent_tra ck |
| IPM-OB | injury to a person | Msg_body_discovered |
| IPM-OB | msg_body discovered | Msg_anomaly_on_current_trac k |
| IPM-OB | injury to a person | Msg_body_discovered |

| | | |
|---|---|---|
| IPM-OB | authorized persons on/near the track | Msg_railway_agent_presence |

### 10.9.5 C 24

| With | Functional Exchange | Exchange Item |
|---|---|---|
| ATO-AV | train or vehicle in opposite direction | Msg_crossing_train |
| ATO-AV | trainset / wagons parked on the track | Msg_vehicle_or_buffer_stop |
| ATO-AV | coupler compression | Msg_coupler_compression |
| ATO-AV | sensor efficiency distance | Msg_sensor_efficiency |
| ATO-AV | trainset / wagons parked on the track | Msg_vehicle_or_buffer_stop |

### 10.9.6 C 47

| With | Functional Exchange | Exchange Item |
|---|---|---|
| TCMS | video stream | Msg_track_video |
| TCMS | video stream request | Cmd_video |

### 10.9.7 C 39

| With | Functional Exchange | Exchange Item |
|---|---|---|
| SCV | signal aspect | Signal aspect |
| SCV | lineside signal expected | Next signal position |

### 10.9.8 C 46

| With | Functional Exchange | Exchange Item |
|---|---|---|
| Light Signal | signal aspect | Signal information |

### 10.9.9 C 61

| With | Functional Exchange | Exchange Item |
|---|---|---|

| | | |
|---|---|---|
| Physical Environment | luggage in train | Train interior event detected |
| Physical Environment | passenger inside train | Train interior event detected |
| Physical Environment | passenger behavior | Train interior event detected |

## 10.10Route Control

This logical component controls the setting and locking of the routes.

SIL: 4

This component is outside the scope of GoA34.

### 10.10.1 Allocated Functions

- Open/Close signals

## 10.11SCV

The Signal Converter is in the train and converts the information coming from optical signals into subset-026 compliant information.

SIL: to be defined

This component is outside the scope of GoA34 (Tauro project).

### 10.11.1 Allocated Functions

- Convert signalling information
- Interpret lineside signalling
- Inform IM about prolonged stop
- Manage supervision orders

## 10.12Traffic Management

This logical component interfaces with IM to manage the traffic and ATO-AT via SS-131.

SIL: 0

This component is outside the scope of GoA34.

### 10.12.1 Allocated Functions

- Manage traffic
- Manage stopping points and passing points
- Protect from high voltage switch on

## 10.13 Train Management

| |
|---|
| This trackside logical component supervises the train missions, it provides the Mission Profile to ATO-AV and permits remote control actions on TCMS.<br><br>SIL: 0<br><br>This component is outside the scope of GoA34. |

### 10.13.1 Allocated Functions

- Determine mission data
- Request train wake-up
- Manage ECM request
- Monitor trains
- Forbid start
- Ensure communication with passengers
- Provide video stream
- Process remote driving commands
- Register autonomous train unit
- Manage TPS request
- Manage Remote Driver request

## 10.14 Train Control

| |
|---|
| This logical component provides the Movement Authorities to the trains.<br><br>SIL: 4<br><br>This component is outside the scope of GoA34. |

### 10.14.1 Allocated Functions

- Transmit start order
- Transmit Emergency Stop
- Transmit override order
- Transmit immobilization order
- Transmit restrictions order
- Transmit TSR
- Transmit adhesion factor

- Transmit MA
- Track train units

## 10.15Train Protection

| |
|---|
| This logical component is in the train and keeps the train inside its safety envelope.<br><br>SIL: 4<br><br>This component is outside the scope of GoA34. |

### 10.15.1 Allocated Functions

- Monitor train integrity
- Train trip
- Store Train Protection parameters
- Manage exchanges with driver
- Monitor speed and distance
- Supervise runaway movement
- Command Emergency Brake
- Command pantograph and main switch
- Supervise emergency brake chain test
- Compute train unit position
- Determine ETCS mode
- Command and supervise horn
- Compute static and dynamic data for ATO

# 11 Description of Logical Functions

## 11.1 Introduction

11.1.1.1.1 The logical functions are associated to a logical architecture (see Figure 6.1), they are allocated to logical components (system functions) and actors (actor functions). The functional exchanges allocated to a logical interface will be characterized in the data dictionary through Exchange Items.

11.1.1.1.2 The logical functions are elementary, the functional decomposition is performed until the level where a function can be allocated to only one component.

11.1.1.1.3 Each function is described with its associated inputs, outputs and logical component where it is allocated. The modes where the function is active will be documented in a next version of this specification.

11.1.1.1.4 This chapter gives only the last level of functional decomposition performed in the model.

11.1.1.1.5 Remark: an output can be repeated several times when it is used by different destination functions.

## 11.2 Description of actor functions

### 11.2.1 Check-out/Check-in vehicle

<u>Description:</u>

| |
|---|
| In this function, Remote Driver takes the responsibility of the train:<br><br>- Remote driving activities can start when the intervention request is accepted by the system (train is then under Remote Driver responsibility). Vehicle is checked-out.<br><br>- Responsibility is given back to the system when all conditions are satisfied (train is then under system responsibility). Vehicle is checked-in. |

| Inputs | Outputs |
|---|---|
| - train under remote driver responsibility | - remote control request<br>- train under system responsibility |

<u>Allocated to:</u>

- Driver

### 11.2.2 Detect obstacles

Description:

| |
|---|
| In this function, Driver monitors the track and adjacent areas:<br>- Detect obstacles and react/report accordingly<br>- Detect persons and react/report accordingly. |

Allocated to:

- Driver

### 11.2.3 Drive train

Description:

| |
|---|
| In this function, Driver drives train manually in GoA1, optionally in «assisted driving» (DAS):<br>- control traction and brakes<br>- obey to signalling (e.g. OS speed limit)<br>- follow driving constraints (imposed speed limit)<br>- follow emergency orders.<br><br>In GoA2, traction and braking commands are managed by ATO but the driver remains the master of the train and can disengage ATO when necessary. |

| **Inputs** | **Outputs** |
|---|---|
| | - key inserted/removed<br>- ATO engage button<br>- override button<br>- ATO disengage button<br>- TBL control |

Allocated to:

- Driver

### 11.2.4 Drive train remotely

Description:

| |
|---|
| In this function, Driver controls the train remotely with the images coming from the train via C48.<br><br>Note: a camera independent from PER system is expected to be able to drive in case of GoA34 |

| failure. |
| --- |

| Inputs | Outputs |
| --- | --- |
| - video stream | - move forward/backward<br>- video stream request<br>- cmd_brakes<br>- isolation request<br>- door opening request |

Allocated to:

- Driver

### 11.2.5 Manage doors (driver)

Description:

| In this function, Driver manages the door systems:<br>- open/close doors<br>- check that passenger transfer is finished (doorways are clear). |
| --- |

Allocated to:

- Driver

### 11.2.6 Manage freight operation

Description:

| In this function, Driver manages freight operation with shunting movements to support the loading or unloading of freight according to the instructions of the Freight Customer. |
| --- |

Allocated to:

- Driver

### 11.2.7 Manage journey

Description:

| In this function, Driver manages the journey:<br>- Skip next station<br>- Stop at next station. |
| --- |

Allocated to:

- Driver

### 11.2.8 Manage reporting

Description:

| |
|---|
| In this function, Driver manages reporting to IM and RU:<br>- report changes to Physical Railway Environment which affect railway operation (adherence conditions)<br>- evaluate train health. |

Allocated to:

- Driver

### 11.2.9 Perform shunting

Description:

| |
|---|
| In this function, Driver performs shunting operations with the instructions of the Train Preparation Staff. |

Allocated to:

- Driver

### 11.2.10 Stop precisely in station

Description:

| |
|---|
| In this function, Driver manages the station stop:<br>- Stop with precision<br>- Move forward in case of undershooting the stopping point<br>- Move backward in case of overshooting the stopping point (it can be forbidden by national rules). |

Allocated to:

- Driver

### 11.2.11 Check-out/Check-in vehicle

Description:

| |
|---|
| In this function, ECM takes the responsibility of the train parked on a maintenance yard:<br><br>- Maintenance activities can start when the intervention request is accepted by the system (train is then under ECM responsibility). Vehicle is checked-out. |

- Responsibility is given back to the system when all conditions are satisfied (train is then under system responsibility). Possible restrictions on the train can also be sent. Vehicle is checked-in.

| Inputs | Outputs |
|---|---|
| - handover area status<br>- maintenance operation ended (ECM)<br>- train under ECM responsibility | - intervention request<br>- transfer of restrictions<br>- train under system responsibility |

Allocated to:

- ECM

### 11.2.12 Schedule routine maintenance

Description:

In this function, ECM plans the maintenance activities for the trains and informs the Fleet Manager.

Allocated to:

- ECM

### 11.2.13 Organize recovery

Description:

In this function, Emergency Manager takes all actions necessary to put again the service in normal operation.

| Inputs | Outputs |
|---|---|
| - cmd_rescue_team | |

Allocated to:

- Emergency Manager

### 11.2.14 Manage energy demand

Description:

| |
|---|
| In this function, Energy Manager interacts with IM to shutdown the catenary power in case of incident or to restart when a train is blocked in a de-energised section.<br><br>Note 1: Energy Manager could also monitor the power consumption of each train with a specific train device for checking that energy is used with efficiency. Such feedback would permit to analyze the benefits of ATO deployment (see Optimize the consumption) keeping in mind that priority is given to punctuality (saving energy is only possible when margin is available).<br><br>Note 2: a second objective could be to optimize the overall energy distribution taking into account trains regenerating, trains consuming and field (Energy Storage Systems, Reversible Substations...). It should also be possible to consume more at some locations if price is better. |

| **Inputs** | **Outputs** |
|---|---|
| - ask_energy<br>- cmd_shutdown_high_voltage | - msg_energy_on_off<br>- msg_energy_on_off |

Allocated to:

- Energy Manager

#### 11.2.15 Manage power demand

Description:

| |
|---|
| In this function, Energy Manager communicates available power on location and time. For each SP of JP, it is possible to define an allowed current consumption (M_CURRENT) that will be managed by ATO-AV.<br><br>Rationale: power consumption of each train must be adjusted to the available distributed power (preventing overloading, keeping balance and avoiding blackouts). |

Allocated to:

- Energy Manager

#### 11.2.16 Attribute trainset to mission

Description:

| |
|---|
| In this function, Fleet Manager assigns a train from his fleet to the planned mission. |

| Inputs | Outputs |
|---|---|
| | - train allocation |

Allocated to:

- Fleet Manager

### 11.2.17 Communicate freight parameters

Description:

| |
|---|
| In this function, Freight Customer informs the system about the parameters necessary to drive the train according to the nature of freight because it impacts the driving style (steel, coal, liquids, dangerous goods...). |

| Inputs | Outputs |
|---|---|
| | - freight characteristics |

Allocated to:

- Freight Customer

### 11.2.18 Manage infrastructure database

Description:

| |
|---|
| In this function, Infrastructure Manager updates the infrastructure database according to the status of infrastructure and temporary constraints (TSRs, Protections, Work Zones...). |

| Inputs | Outputs |
|---|---|
| | - track anomaly confirmed<br>- track description<br>- maintenance area activated |

Allocated to:

- Infrastructure Manager

### 11.2.19 Display signal aspect

Description:

| |
|---|
| This function displays a signal aspect to Driver. |

| Inputs | Outputs |
|---|---|
| - lineside signalling state | - signal aspect |

Allocated to:

- Light Signal

### 11.2.20 Manage doors (train attendant)

Description:

| |
|---|
| In this function, On-board Staff manages the doors:<br>- confirm that passenger exchange is finished (it is safe to start)<br>- unblock doors (clean sensor/camera, remove obstacle)<br>- estimate the impact of a door problem<br>- disable/enable doors in case of door problem. |

| Inputs | Outputs |
|---|---|
| | - door key |

Allocated to:

- Onboard Staff

### 11.2.21 Request assisted driving

Description:

| |
|---|
| In this function, On-board Staff informs the system that he can take the control of the train. A key or similar mechanism indicates the presence or absence of the train attendant to the system. |

| Inputs | Outputs |
|---|---|
| | - onboard staff key |

Allocated to:

- Onboard Staff

### 11.2.22 Authorize SR movements

Description:

| |
|---|
| In this function, IM authorizes a movement in Staff Responsible mode.<br><br>Assumption: SR authorization is transmitted to Train Protection interfaced with ATO. |

| Inputs | Outputs |
|---|---|
| | - authorization to override |

Allocated to:

- Operations Manager

### 11.2.23 Dispatch orders

Description:

| |
|---|
| In this function, IM transmits the following orders either directly or following RU request:<br><br>- authorization to proceed<br><br>- authorization to close the doors (door closing can be delayed for a person with reduced mobility or forced in case of crowd)<br><br>- start prohibited<br><br>- train immobilization<br><br>- train battery protection. |

| Inputs | Outputs |
|---|---|
| - order request | - authorization to proceed<br>- battery protection request<br>- cmd_request_immobilization<br>- cmd_remove_immobilization<br>- authorization to close the doors<br>- start prohibited |

Allocated to:

- Operations Manager

### 11.2.24 Ensure the monitoring of running trains

Description:

| |
|---|
| In this function, IM monitors the running of the trains on the network via Traffic Management and manages incidents affecting operation (hot axle, traction failure...). A train can be withdrawn for example.<br><br>Assumption: Emergency Stop messages are sent through Train Control, not ATO. |

| Inputs | Outputs |
|---|---|
| - request of information<br>- msg_energy_on_off<br>- operational restrictions<br>- track anomaly<br>- train anomaly<br>- anomaly detected on crossing train<br>- de-energized section<br>- livestock wandering<br>- anomalies of train / tracks / persons dead or injured<br>- local_alarm_raised<br>- train status | - information or orders<br>- ask_energy<br>- action request<br>- order request |

Allocated to:

- Operations Manager

### 11.2.25 Manage possession

Description:

| |
|---|
| In this function, IM controls the track access via Route Control (normal operation or maintenance works for example). |

| Inputs | Outputs |
|---|---|
| | - possession request |

Allocated to:

- Operations Manager

### 11.2.26 Manage temporary speed restriction

Description:

| |
|---|
| In this function, IM can impose a temporary speed restriction that will be sent to Train Protection via SS-026 (TSR) and ATO-AV via SS-126 (ASR). The ASR shall include any TSR defined by the ETCS and may include any operational speed restriction requested by IM or RU. |

| Inputs | Outputs |
|---|---|
| | - speed_restriction_order |

Allocated to:

- Operations Manager

### 11.2.27 Manage track adhesion

Description:

| |
|---|
| In this function, IM manages slippery rail information. |

| Inputs | Outputs |
|---|---|
| | - slippery zone |

Allocated to:

- Operations Manager

#### 11.2.28 Request catenary power shutdown

Description:

| |
|---|
| In this configurable function, IM can request an automatic shutdown of the catenary power in case of specific anomalies detected by the train. |

| Inputs | Outputs |
|---|---|
| - msg_energy_on_off | - cmd_shutdown_high_voltage |

Allocated to:

- Operations Manager

#### 11.2.29 Request protection against high voltage switch on

Description:

| |
|---|
| In this function, IM informs that high voltage switch on is forbidden. |

| Inputs | Outputs |
|---|---|
| | - high voltage switch on forbidden |

Allocated to:

- Operations Manager

#### 11.2.30 Set routes

Description:

| |
|---|
| In this function, IM interfaces with TMS to set the routes for the trains. |

| Inputs | Outputs |
|---|---|
| | - route request |

Allocated to:

- Operations Manager

### 11.2.31 Solve conflicts

Description:

In this function, IM can inhibit automatic train operation for solving conflicts where appropriated. He can cancel a planned route before setting another one for example.

| Inputs | Outputs |
|---|---|
| | - route cancellation request |

Allocated to:

- Operations Manager

### 11.2.32 Take initial actions in case of emergencies

Description:

In this function, IM manages the emergencies at the first level (emergency stop to one train or switch off catenary voltage for example). The second level is ensured by the Emergency Manager.

| Inputs | Outputs |
|---|---|
| - action request | - cmd_ETCS_stop<br>- cmd_ClassB_signal_closure<br>- cmd_rescue_team<br>- order_caution_speed+observation |

Allocated to:

- Operations Manager

### 11.2.33 Command doors opening

Description:

| |
|---|
| In this function, Passenger opens the doors unlocked by TCMS. |

| Inputs | Outputs |
|---|---|
| | - door opening request |

Allocated to:

- Passenger

### 11.2.34 Speak and listen

Description:

| |
|---|
| In this function, Passenger is in communication with RU. |

| Inputs | Outputs |
|---|---|
| - RU voice | - passenger voice |

Allocated to:

- Passenger

### 11.2.35 Trigger alarm signal

Description:

| |
|---|
| In this function, Passenger triggers an emergency request or pushes the call for help button. |

| Inputs | Outputs |
|---|---|
| | - signal alarm triggered |

Allocated to:

- Passenger

### 11.2.36 Trigger events

Description:

| |
|---|
| This function models all events related to Physical Environment that must be detected by the system to trigger an appropriated action. |

| Inputs | Outputs |
|---|---|
| | - luggage in train<br>- passenger inside train<br>- vehicle on track<br>- railway agent<br>- abnormal noise<br>- sparks on a roof<br>- flooding<br>- track anomaly<br>- live stock wandering<br>- catenary anomaly<br>- body discovered<br>- flooding (adjacent track)<br>- track anomaly (adjacent track)<br>- level crossing damage<br>- catenary anomaly (adjacent track)<br>- body discovered<br>- crossing train anomalies<br>- external fire<br>- railway agent signal<br>- train body dynamic<br>- axle rotation at low speed<br>- incident caused by the train<br>- passenger behavior<br>- vehicle on track<br>- crossing train in approach<br>- crossing train anomalies<br>- uncontrolled train<br>- train side anomaly<br>- strucked person |

Allocated to:

- Physical Environment

### 11.2.37 Move along the track

Description:

| |
|---|
| In this function, Physical Train Unit moves along the track according to the driving commands of ATO or Driver. |

| Inputs | Outputs |
|---|---|
| | - train movement |

Allocated to:

- Physical Train Unit

### 11.2.38 Be identified like an autonomous train

Description:

| |
|---|
| In this function, Physical Train Unit activates a specific light to identify the train as an autonomous one. |

| Inputs | Outputs |
|---|---|
| - autonomous train light is ON | |

Allocated to:

- Physical Train Unit

### 11.2.39 Define mission

Description:

| |
|---|
| In this function, RU defines the missions of the passenger and/or freight trains. For each mission, the sequence of tasks is elaborated. |

| Inputs | Outputs |
|---|---|
| - train allocation<br>- request task addition | - start and destination point of the train unit<br>- wagon to be taken into account<br>- load particularity<br>- requested mission<br>- updated mission<br>- train allocation<br>- local instructions<br>- request powered ATO |

Allocated to:

- Railway Undertaking Supervisor

#### 11.2.40 Communicate with passengers

Description:

| |
|---|
| In this function, RU can communicate with passengers (verbal communication + specific messages for TIS) and monitors train interior via a closed-circuit television. |

| Inputs | Outputs |
|---|---|
| - live_interior_video<br>- verbal communication | - msg_ information_about_incident<br>- verbal communication<br>- cmd_request_interior_video |

Allocated to:

- Railway Undertaking Supervisor

#### 11.2.41 Manage vehicle database

Description:

| |
|---|
| In this function, RU updates the vehicle database (National Vehicle Register). |

| Inputs | Outputs |
|---|---|
| - freight characteristics | - vehicle characteristics |

Allocated to:

- Railway Undertaking Supervisor

### 11.2.42 Request video stream

Description:

| |
|---|
| In this function, RU requests a video stream of the train environment to support remote control operation. |

| Inputs | Outputs |
|---|---|
| - video stream | - video stream request |

Allocated to:

- Railway Undertaking Supervisor

### 11.2.43 Supervise trains

Description:

| |
|---|
| In this function, RU must evaluate the impact of train anomalies on the planned mission and removes related alarms when relevant. RU can also prohibit the train departure and unlocks the immobilization status after conflict resolution. |

| Inputs | Outputs |
|---|---|
| - information or orders<br>- alarm signal<br>- intervention required<br>- local_alarm_raised<br>- de-energized section<br>- livestock wandering<br>- anomalies of train / tracks / persons dead or injured<br>- train anomaly<br>- track anomaly | - request of information<br>- passenger alarm reset<br>- lock_coach<br>- delay_door_closing<br>- cmd train wake-up<br>- operational restrictions |

Allocated to:

- Railway Undertaking Supervisor

### 11.2.44 H.D Manage train modes

Description:

| |
|---|
| This function manages the transitions between TCMS modes (see UIC 612). The interfaces currently identified with ATO are:<br><br>- TCMS driving mode (normal, coupling, emergency, washing, transition, shunting)<br><br>- Battery protection mode<br><br>- Service retention mode (or Stand-by) after TCMS inauguration (to be confirmed)<br><br>- TCMS Remote Control mode (ATO must not interfere during RC). |

| Inputs | Outputs |
| --- | --- |
| - cmd driving mode<br>- cmd power on train<br>- cmd service retention mode<br>- cmd shutdown mode<br>- remote control mode ON/OFF<br>- cmd train wake-up<br>- cmd battery protection mode | - train inauguration<br>- splitting done<br>- TCMS mode<br>- TCMS in service retention mode<br>- TCMS in shutdown mode<br>- vehicle powered<br>- TCMS in RC mode<br>- TCMS in RC mode<br>- TCMS mode<br>- autonomous train light is ON<br>- parking brake requested |

Allocated to:

- TCMS

### 11.2.45 H.E.H Manage control of the train parameters

Description:

| |
| --- |
| This function controls the train parameters (mission parameters, time...). |

| Inputs | Outputs |
| --- | --- |
| | - braking capacity<br>- mass on the rail<br>- train length<br>- obtained braked weight<br>- train composition<br>- train length<br>- train length<br>- train composition and brake capacity data<br>- train composition<br>- train parameters<br>- wagon type - characteristics<br>- train length<br>- train category<br>- maximum train speed<br>- maximum train speed |

Allocated to:

- TCMS

### 11.2.46 H.E.H.F Manage isolation of devices

Description:

This function permits to isolate a specific function of TCMS.

| Inputs | Outputs |
| --- | --- |
| - isolation request | |

Allocated to:

- TCMS

### 11.2.47 H.H Assist troubleshooting

Description:

| This TCMS function is linked to H.G Provide diagnostics and reports train anomalies that can have an impact on operation. Analysis and actions currently performed by the driver must be performed automatically by the system in GoA4. |
|---|

| Inputs | Outputs |
|---|---|
| - shunting compensator default<br>- charger default<br>- light non-sufficient in one area<br>- loss in fluid energy<br>- cmd self-diagnose & repair<br>- HVAC default<br>- hot box<br>- door diagnostic<br>- catenary voltage<br>- pantograph diagnostic<br>- suspension diagnostic<br>- TIS status<br>- interior light level | - potential trackside train detection problem<br>- msg_main_battery_power_level<br>- loss in fluid energy<br>- hot box<br>- door failure<br>- current gap detected<br>- pantograph problem<br>- suspension problem<br>- HVAC failure<br>- loss in fluid energy<br>- TIS problem<br>- door failure<br>- pantograph problem<br>- suspension status<br>- TIS problem<br>- high_voltage_anomaly<br>- HVAC failure<br>- interior light failure<br>- maintenance data<br>- EB brake failure<br>- broken window<br>- degraded braking capacity<br>- degraded traction capacity<br>- train consist failure<br>- fluid level for non-electric engines |

Allocated to:

- TCMS

### 11.2.48 H.H-W.E Provide Maintenance

Description:

This function is informed by TCMS of a problem and tries to fix it with specific commands:

- air suspension isolation

- use of second pantograph

- leak isolation

- window release

- door locking.

A new configuration has an impact on train performance.

Note: This function could be renamed in H.H.D «Provide guidance to the driver to continue the mission» but there is no more driver in GoA4 to take the relevant actions. Merging with H.H. Assist troubleshooting can be considered in case of automatic TCMS action. Alternative is to keep the function for interfacing with a remote control in GoA34 or a train attendant in GoA3.

| **Inputs** | **Outputs** |
|---|---|
| - TIS problem<br>- pantograph problem<br>- suspension problem<br>- HVAC failure<br>- loss in fluid energy<br>- door failure | - isolation request<br>- cmd_use_of_second_pantograph<br>- cmd self-diagnose & repair<br>- release windows<br>- cmd_lock_out_of_service door |

Allocated to:

- TCMS

### 11.2.49 G.B Provide acceleration

Description:

This function controls traction and includes G.B.C Acquire propulsion demand from the ATO.

Alternative: H.E.C Manage propulsion and brake demand.

| Inputs | Outputs |
|---|---|
| - cmd traction off<br>- cmd traction force<br>- cmd accurate traction force<br>- cmd traction force<br>- traction = neutral | - measured traction force<br>- measured traction force<br>- measured traction force<br>- measured traction force |

Allocated to:

- TCMS

### 11.2.50 H.B.E Provide train radio information

Description:

This function manages the train radio information when this device is present. It changes the channel of the voice radio communication system when requested and sends train radio alarm. The function provides the status of the track-to-train radio. An anomaly must be known by the system because it is used by driver to communicate an emergency order (not necessary in GoA4).

| Inputs | Outputs |
|---|---|
| - cmd track-to-train radio OFF (specific)<br>- cmd track-to-train radio ON (specific)<br>- cmd change of radio channel (specific)<br>- track-to-train radio alarm (specific) | - track-to-train radio status (specific)<br>- cmd_alarm |

Allocated to:

- TCMS

### 11.2.51 H.C.B Inaugurate train network

Description:

| |
|---|
| This function performs the train inauguration to determine train configuration (count, order, direction and capabilities of the consists). |

| Inputs | Outputs |
|---|---|
| - train orientation<br>- train orientation | - train configuration<br>- travelling direction 1 or 2<br>- travelling direction 1 or 2<br>- train configuration<br>- travelling direction 1 or 2<br>- travelling direction 1 or 2 |

Allocated to:

- TCMS

### 11.2.52 H.E.B Manage cab control

Description:

| |
|---|
| This function controls the cab and its functionality. A specific action from the driver is necessary to unlock the driving desk and take control of the traction brake controller.<br><br>The following sub-functions are given for information:<br><br>- H.E.B.B Ensure access control in the cab<br><br>- H.E.B.C Manage cab activation<br><br>- H.E.B.E Manage cab deactivation<br><br>- H.E.B.F Prevent master conflict due to more than one activated cab. |

| Inputs | Outputs |
|---|---|
| - key inserted/removed<br>- lock controls<br>- lock controls<br>- unlock controls<br>- unlock controls<br>- onboard staff key | - desk status |

Allocated to:

- TCMS

### 11.2.53 H.E.E Manage windscreen cleaning

Description:

| |
|---|
| This function is optional (train with a driving desk) and switches on/off the wipers when requested (sensor and/or action from driver).<br><br>Assumption: no interface with the system. |

Allocated to:

- TCMS

### 11.2.54 H.E.H.G Provide remote control

Description:

| |
|---|
| This function gives access to TCMS for remote control. RU has access to this mode in degraded situations for moving the trains on a limited distance at low speed. EM has access to this mode to move the train on a distance of 1m or less to check a blocked axle or evacuate a trapped body.<br><br>Note: In this remote control mode, TCMS acts directly on traction or brakes (bypass of Train Protection or ATO commands). |

| Inputs | Outputs |
|---|---|
| - move forward/backward<br>- cmd_brakes<br>- ETCS isolation request<br>- door opening request | - remote control speed |

Allocated to:

- TCMS

### 11.2.55 H.E.J Manage exterior lighting

Description:

This function switches on/off the front and rear lights of the train when requested and reports an anomaly when a light failure is detected.

| Inputs | Outputs |
|---|---|
| - cmd headlights front/rear<br>- cmd light alarm signal test (specific)<br>- cmd light alarm signal (specific)<br>- TCMS mode<br>- cmd headlights/dipped headlights<br>- loss of headlights | - headlights front/rear status<br>- light alarm signal status (specific)<br>- information train immobilized<br>- loss of headlights |

Allocated to:

- TCMS

### 11.2.56 H.E.J Manage acoustic warning system

Description:

This function activates the horn.

| Inputs | Outputs |
|---|---|
| - horn request<br>- horn sound | - cmd horn<br>- horn status<br>- horn disturbed |

Allocated to:

- TCMS

### 11.2.57 F.B.E Protect collection devices and catenary

Description:

This function protects against use of high voltage when maintenance or cleaning operations are performed on the train.

| Inputs | Outputs |
|---|---|
| - cmd local protection ON (staff)<br>- cmd local protection OFF (staff)<br>- cmd local protection OFF (ECM)<br>- cmd local protection ON (ECM) | - local protection status<br>- local protection status |

Allocated to:

- TCMS

### 11.2.58 F.C.H Provide low voltage DC supply

Description:

This function switches on/off the low voltage contactors from battery when requested.

| Inputs | Outputs |
|---|---|
| - cmd closure low voltage contactors<br>- cmd opening low voltage contactors | |

Allocated to:

- TCMS

### 11.2.59 F.F.D Generate mechanical energy for traction

Description:

| |
|---|
| This function starts the non-electric engine (diesel, H2, CNL...) when requested and when authorized. |

| Inputs | Outputs |
|---|---|
| - cmd engine start<br>- local protection status | |

Allocated to:

- TCMS

### 11.2.60 H.E.D Manage energy supply for traction

Description:

| |
|---|
| This function activates the raise/lower pantograph commands and switches on/off the main circuit breaker when requested. |

| Inputs | Outputs |
|---|---|
| - cmd lower pantograph<br>- cmd raise pantograph<br>- cmd_pantograph_drop<br>- cmd_pantograph_drop<br>- cmd_use_of_second_pantograph<br>- cmd main circuit breaker opening<br>- cmd main circuit breaker closure<br>- request main circuit breaker closure (2)<br>- request main circuit breaker opening (2)<br>- cmd main circuit breaker closure<br>- cmd main circuit breaker opening<br>- cmd lower pantograph<br>- cmd raise pantograph | - pantograph diagnostic<br>- pantograph position<br>- pantograph position |

Allocated to:

- TCMS

### 11.2.61 H.E.D Manage energy supply for auxiliaries

Description:

| |
|---|
| This function switches on/off power supply of auxiliaries (HVAC, lights, battery, compressor...) when requested i.e. train preparation. |

| Inputs | Outputs |
|---|---|
| - cmd stop auxiliaries<br>- cmd start auxiliaries | - power supply OK<br>- power supply OK<br>- power supply OK<br>- auxiliaries status |

Allocated to:

- TCMS

### 11.2.62 G.C.F.C.E Provide Brake Command for Emergency Braking

Description:

| |
|---|
| This function receives the emergency brake command and opens the brake pipe.<br><br>Note: G.C.C includes commands for all brakes, emergency brake is one of them. |

| Inputs | Outputs |
|---|---|
| - cmd EB<br>- msg_loss_of_integrity<br>- vigilance signal<br>- vigilance inhibition<br>- cmd_release_EB_order | - cmd_EB |

Allocated to:

- TCMS

### 11.2.63 G.C.F.C.E-W.A Provide Test (Emergency Brake)

Description:

| |
|---|
| This function tests effective application of the emergency brake command. |

| Inputs | Outputs |
|---|---|
| - cmd test EB | - EB test status |

Allocated to:

- TCMS

### 11.2.64 G.C.B Configure brake system

Description:

| |
|---|
| This function configures the brake system:<br><br>- it opens/closes the valve between main reservoir pipe and brake pipe when requested.<br><br>- it measures the air pressure in main reservoir pipe (yellow pipe) and brake pipe (red pipe). |

- it regulates the air pressure in the brake pipe according to the request.

- it switches on the electro-pneumatic brake when requested for the trains equipped with such system.

| Inputs | Outputs |
|---|---|
| - cmd overload pressure off<br>- cmd overload pressure off<br>- cmd brake pipe = reference pressure<br>- cmd decrease in pressure of 1 bar<br>- cmd braking pipe filing with high flow<br>- cmd overload pressure ON<br>- cmd overload pressure ON<br>- cmd overload pressure ON<br>- cmd brake pressure = 0,5 bar<br>- cmd brake pressure = 4 bar -> 3 bar<br>- brake pressure<br>- cmd opening of main pipe/brake pipe link<br>- cmd opening of main pipe/brake pipe link<br>- cmd opening of main pipe/brake pipe link<br>- cmd closing of main pipe/brake pipe link<br>- cmd closing of main pipe/brake pipe link<br>- cmd electro-pneumatic brake ON<br>- cmd brake pipe = 0 bar<br>- request brake test sequence after coupling<br>- request brake test sequence without coupling<br>- request brake release sequence<br>- choice of braking regime<br>- braking regime<br>- cmd closing of main pipe/brake pipe link<br>- cmd overload pressure ON<br>- cmd opening of main pipe/brake pipe link | - braking pressure<br>- leak noise<br>- main pipe pressure<br>- brake pipe pressure<br>- brake pipe pressure<br>- brake pipe pressure<br>- brake pipe pressure<br>- main pipe pressure<br>- main pipe pressure<br>- main pipe pressure<br>- main pipe pressure<br>- sudden decrease of pressure<br>- brake pipe pressure |

Allocated to:

- TCMS

### 11.2.65 G.C.C Acquire brake demand (direct brake)

Description:

| |
|---|
| This function activates the direct brake of the locomotive when requested by ATO.<br><br>Note: The direct brake is also known as the independent brake or straight air brake. |

| Inputs | Outputs |
|---|---|
| - cmd direct brake release<br>- cmd direct brake release<br>- cmd direct brake application<br>- cmd direct brake application<br>- cmd direct brake application<br>- cmd brake for accurate stop<br>- cmd direct brake application | - direct brake applied<br>- direct brake applied<br>- direct brake applied |

Allocated to:

- TCMS

### 11.2.66 G.C.F.C.B Provide Brake Command for Parking Braking

Description:

| |
|---|
| This function applies or releases the parking brakes. |

| Inputs | Outputs |
|---|---|
| - parking brake requested<br>- parking brake requested | |

Allocated to:

- TCMS

### 11.2.67 G.C.F.C.C Provide Brake Command for Holding Braking

Description:

| |
|---|
| This function applies or releases the holding brakes. |

| Inputs | Outputs |
|---|---|
| - holding brake release<br>- holding brake request | - holding brake status<br>- holding brake status |

Allocated to:

- TCMS

### 11.2.68 G.C.F.C.D Provide Brake Command for Service Braking

Description:

| |
|---|
| This function applies or releases the service brakes. |

| Inputs | Outputs |
|---|---|
| - cmd brake during itinerary<br>- cmd Service Brake | - SB command |

Allocated to:

- TCMS

### 11.2.69 G.C.F.F Acquire realised braking effort

Description:

| |
|---|
| This function acquires the realised brake effort. |

| Inputs | Outputs |
|---|---|
| | - measured brake force<br>- measured brake force<br>- measured brake force |

Allocated to:

- TCMS

### 11.2.70 G.C.G Apply and release braking forces

Description:

| |
|---|
| This function applies or releases the braking effort:<br><br>- generate braking forces by friction brake<br><br>- generate braking forces by eddy-current brake<br><br>- generate braking forces by magnetic track brake<br><br>- command electrodynamic brake<br><br>- release braking forces (including emergency release). |

| Inputs | Outputs |
|---|---|
| - braking pressure<br>- cmd_EB<br>- SB command | - brake shoe position<br>- brake shoe position |

Allocated to:

- TCMS

### 11.2.71 D.B Provide external access

Description:

| |
|---|
| This function groups all needs associated with the management of the external doors. |

| Inputs | Outputs |
|---|---|
| - cmd_lock_out_of_service  door | - door diagnostic |

Allocated to:

- TCMS

### 11.2.72 D.B.B Release external doors

Description:

| This function releases the doors of an intelligent door system when requested and when the train is at standstill. It enables the doors to be opened by passengers. |
|---|

| Inputs | Outputs |
|---|---|
| - door enable request | - doors status = released |

Allocated to:

- TCMS

### 11.2.73 D.B.C Open external doors

Description:

| This function opens the doors of an intelligent door system when requested. Depending on configuration, doors can be opened by passengers. |
|---|

| Inputs | Outputs |
|---|---|
| - door open request<br>- door opening request<br>- door opening parameters<br>- door key | - door status = open |

Allocated to:

- TCMS

### 11.2.74 D.B.D Close external doors

Description:

| This function closes and locks the doors of an intelligent door system when requested. |
|---|

| Inputs | Outputs |
|---|---|
| - door close request<br>- request door closure (1)<br>- request door closure (2) | - doors status = closed and locked |

Allocated to:

- TCMS

### 11.2.75 D.B.E Manage door system upon obstacle

Description:

| |
|---|
| This function detects an obstacle during door closing. |

| Inputs | Outputs |
|---|---|
| | - obstacle |

Allocated to:

- TCMS

### 11.2.76 D.B.M Signal external door status change/open/close

Description:

| |
|---|
| This function activates the buzzer and lights of an intelligent door system when requested. |

| Inputs | Outputs |
|---|---|
| - cmd buzzer and lights | |

Allocated to:

- TCMS

### 11.2.77 D.B.P Reduce the gap between vehicle and platform

Description:

| |
|---|
| This function manages the bridging plate and the mobile step of an intelligent door system when requested. These devices reduce the distance and the height between platform and train floor |

level.

| Inputs | Outputs |
|---|---|
| - cmd cancellation of bridging plates and mobile step<br>- cmd bridging plates and mobile step | - bridging plate and mobile step closed |

Allocated to:

- TCMS

### 11.2.78 D.C Provide access by internal door

Description:

This function isolates a coach by locking its interior doors to forbid passenger access (broken window for example).

Note: a similar action is expected on the external doors (D.B.K Isolate external doors).

| Inputs | Outputs |
|---|---|
| - lock_coach | |

Allocated to:

- TCMS

### 11.2.79 E.B.B Open cover

Description:

This function opens the coupler trapdoors before coupling when requested.

| Inputs | Outputs |
|---|---|
| - cmd open close trapdoor | |

Allocated to:

- TCMS

### 11.2.80 E.B.B Prepare the coupling

Description:

| |
|---|
| This function heats the coupler when requested (winter conditions).<br><br>Note: this function could also be performed automatically by TCMS when train is awakened if outside temperature is below a given threshold. In case of failure, an anomaly must be reported. For existing trains without TCMS, an adapter function must be provided. |

| Inputs | Outputs |
|---|---|
| - cmd_heat_coupler | |

Allocated to:

- TCMS

### 11.2.81 E.B.C Manage uncoupling

Description:

| |
|---|
| This function manages the coupler splitting when requested. |

| Inputs | Outputs |
|---|---|
| - cmd splitting | |

Allocated to:

- TCMS

### 11.2.82 E.B.C Close cover

Description:

| |
|---|
| This function closes the coupler trapdoors after uncoupling when requested. |

Allocated to:

- TCMS

### 11.2.83 C.E.F. Provide possibility to open windows

Description:

| |
|---|
| This function is currently performed by passengers or train attendant and permits to supply clean fresh air in a coach in case of TCMS or HVAC failure. Window is the current solution but alternatives are possible (emergency exit in a secured area for example).<br><br>For GoA3, this need is fulfilled with train attendant. For GoA4, this need is a constraint exported to TCMS. |

| Inputs | Outputs |
|---|---|
| - release windows | |

Allocated to:

- TCMS

### 11.2.84 H.E.E Manage appropriate and safe conditions

Description:

| |
|---|
| This function controls comfort and safety functionality.<br><br>It is expected that this function has dedicated sensors for monitoring weather conditions. |

| Inputs | Outputs |
|---|---|
| | - weather information |

Allocated to:

- TCMS

### 11.2.85 H.E.E.F Manage interior lighting

Description:

| |
|---|
| This function activates the lights inside a passenger train when requested.<br><br>If the light is not sufficient in a given area (lamp failure or even tags on windows reducing the lighting to 70% or less), the passengers have to be transferred to a safer zone. |

| Inputs | Outputs |
|---|---|
| - cmd passenger light OFF<br>- cmd passenger light ON | - light non-sufficient in one area<br>- light status |

Allocated to:

- TCMS

### 11.2.86 H.E.E.G Manage climatisation

Description:

This function switches on/off the heating, ventilation and air-conditioning system when requested.

| Inputs | Outputs |
|---|---|
| - cmd HVAC OFF<br>- cmd HVAC ON<br>- cmd_ventilation_without_energy | - HVAC default<br>- HVAC status |

Allocated to:

- TCMS

### 11.2.87 B.E.D Manage signalling of fire

Description:

This function ensures the management of fire alert, fire warning and notification of fire.

| Inputs | Outputs |
|---|---|
| - fire on board | - fire on board<br>- cmd_fire_extinguisher |

Allocated to:

- TCMS

### 11.2.88 B.E.E Manage/Provide fire extinguishment

Description:

| This function extinguishes fire when requested (sprinkler system for example). |
|---|

| Inputs | Outputs |
|---|---|
| - cmd_fire_extinguisher | |

Allocated to:

- TCMS

### 11.2.89 C.F.D Manage emergency alarm from passengers

Description:

| This function detects the passenger alarms: call for help button and emergency request. |
|---|

| Inputs | Outputs |
|---|---|
| - signal alarm triggered<br>- passenger alarm reset | - alarm signal<br>- alarm signal |

Allocated to:

- TCMS

### 11.2.90 C.F.F. Provide passenger emergency intercommunication

Description:

| This function ensures verbal communication between TCMS and passengers for connecting RU with his passengers. |
|---|

| Inputs | Outputs |
|---|---|
| - passenger voice<br>- verbal communication | - RU voice<br>- verbal communication |

Allocated to:

- TCMS

### 11.2.91 F.B.B Sense catenary voltage

Description:

| |
|---|
| This function measures the catenary voltage for pantograph monitoring purpose.<br><br>Assumption: function internal to TCMS (no interface with the system). |

| Inputs | Outputs |
|---|---|
| | - catenary voltage |

Allocated to:

- TCMS

### 11.2.92 F.C.H.B Provide charging

Description:

| |
|---|
| This function provides energy to battery and reports an anomaly in case of charger default. |

| Inputs | Outputs |
|---|---|
| | - charger default |

Allocated to:

- TCMS

### 11.2.93 F.E Provide fluid energy for auxiliaries

Description:

| |
|---|
| This function provides energy through hydraulic or pneumatic media to auxiliaries (brake system, doors, pantograph...) and reports an anomaly in case of loss in fluid energy. |

| Inputs | Outputs |
|---|---|
| | - loss in fluid energy |

Allocated to:

- TCMS

#### 11.2.94 F.H Provide chemical energy for traction

Description:

| |
|---|
| This function provides the fluid levels associated to a non-electric engine (diesel, H2, CNL...) to ensure that mission can be performed. |

| Inputs | Outputs |
|---|---|
| | - fluid levels |

Allocated to:

- TCMS

#### 11.2.95 G.C.H Detect sliding

Description:

| |
|---|
| This function detects slipping during traction and skidding during braking. |

| Inputs | Outputs |
|---|---|
| | - grip/ground adhesion problem<br>- sliding detected |

Allocated to:

- TCMS

#### 11.2.96 G.D.B Command sanding

Description:

| |
|---|
| This function delivers sand on the track when requested. |

| Inputs | Outputs |
|---|---|
| - cmd opening/closure sandbox<br>- sand suppression command | |

Allocated to:

- TCMS

### 11.2.97 H.E.E Manage surveillance system

Description:

| |
|---|
| This function gives access to train interior images on request from RU. |

| Inputs | Outputs |
|---|---|
| - cmd_request_interior_video | - live_interior_video |

Allocated to:

- TCMS

### 11.2.98 J.B.C Provide derailment information

Description:

| |
|---|
| This function detects derailment occurring on a trainset by monitoring relevant on board parameters with an acceptable reliability in any allowable service condition. |

| Inputs | Outputs |
|---|---|
| | - bogie instability detected |

Allocated to:

- TCMS

### 11.2.99 J.B.E Remove obstacle on the track

Description:

| |
|---|
| This function protects the bogie and its equipment from damage caused by a collision with obstacles lying on top of the rails. It removes snow from the area in front of the train.<br><br>Note: this protection ejects the small objects not considered like incidents by IPM. |

Allocated to:

- TCMS

### 11.2.100 J.B.H Monitor wheelset bearing status

Description:

| |
|---|
| This function defines criteria, corresponding threshold and response time to define necessity of maintenance or operating measures.<br><br>It includes 2 subfunctions:<br><br>- J.B.H Detect hot axle box bearing temperature to detect unusual temperature increase of an axle box.<br><br>- J.B.H Signal hot axle box bearing temperature to trigger a speed reduction or a stop according to heating values. |

| Inputs | Outputs |
|---|---|
| - hot box | - hot box |

Allocated to:

- TCMS

### 11.2.101 J.B.K Provide a suspension diagnostic

Description:

| |
|---|
| This function monitors air suspension and reports an anomaly when a failure is detected. |

| Inputs | Outputs |
|---|---|
| | - suspension diagnostic |

Allocated to:

- TCMS

### 11.2.102 K.D.C Provide train to ground communication

Description:

| |
|---|
| This function ensures communication with RU. |

| Inputs | Outputs |
|---|---|
| - video stream<br>- video stream request | - video stream request<br>- video stream |

Allocated to:

- TCMS

#### 11.2.103 K.D.C.B Alarming mechanism to the ground (shunting circuit compensator state)

Description:

| |
|---|
| This function gives the status of the shunting circuit compensator associated to specific trains. This device enforces the wheel/rail contact.<br><br>Rationale: country specific for tracks equipped with track circuits and where shunting can be affected (non-electrified lines, low traffic, sand in a point area). |

| Inputs | Outputs |
|---|---|
| | - shunting compensator default |

Allocated to:

- TCMS

#### 11.2.104 Couple locomotive

Description:

| |
|---|
| In this function, Train Preparation Staff couples manually freight wagons to the locomotive to finalize the coupling operation and informs the system when coupling is ok. |

| Inputs | Outputs |
|---|---|
| | - coupling ok |

Allocated to:

- Train Preparation Staff

### 11.2.105 Request compression

Description:

| |
|---|
| In this function, Train Preparation Staff requests a compression effort on the coupler to start the uncoupling of the loco. |

| Inputs | Outputs |
|---|---|
| - information train immobilized | - request compression |

Allocated to:

- Train Preparation Staff

### 11.2.106 Request coupling

Description:

| |
|---|
| In this function, Train Preparation Staff requests a coupling operation for the locomotive. |

| Inputs | Outputs |
|---|---|
| - information train immobilized | - request coupling |

Allocated to:

- Train Preparation Staff

### 11.2.107 Uncouple locomotive

Description:

| |
|---|
| In this function, Train Preparation Staff uncouples manually freight wagons from the locomotive to finalize the uncoupling operation and informs the system when uncoupling is ok. |

| Inputs | Outputs |
|---|---|
| | - uncoupling OK |

Allocated to:

- Train Preparation Staff

### 11.2.108 Request brake test

Description:

| |
|---|
| In this function, Train Preparation Staff requests ATO to perform a brake test on a freight train. |

| Inputs | Outputs |
|---|---|
| | - apply brake request |

Allocated to:

- Train Preparation Staff

### 11.2.109 Check brake pressure

Description:

| |
|---|
| In this function, Train Preparation Staff checks the brake pressure during the test of the electro-pneumatic brake and informs the system when the test is ok. |

| Inputs | Outputs |
|---|---|
| | - electro-pneumatic brake test ok |

Allocated to:

- Train Preparation Staff

### 11.2.110 Check conformity of brake data

Description:

| |
|---|
| In this function, Train Preparation Staff checks conformity of the brake data after freight train composition.<br><br>Rationale: without DAC, TPS must confirm the brake test (encapsulated data are sent through MP). |

| Inputs | Outputs |
|---|---|
| - brake parameters + modification | - brake parameters + modification |

Allocated to:

- Train Preparation Staff

### 11.2.111 Determine brake test to trigger

Description:

| |
|---|
| In this function, Train Preparation Staff determines the brake test to trigger depending on the loco configuration and communicates this information to the system. |

| Inputs | Outputs |
|---|---|
| - brake parameters + modification | - brake test type requested |

Allocated to:

- Train Preparation Staff

### 11.2.112 Request brake release

Description:

| |
|---|
| In this function, Train Preparation Staff requests ATO to release the brakes. |

| Inputs | Outputs |
|---|---|
| - brake application OK | - release brake request |

Allocated to:

- Train Preparation Staff

### 11.2.113 Elaborate brake data

Description:

| |
|---|
| In this function, Train Preparation Staff elaborates  the brake data of the freight train defined in the mission. |

| Inputs | Outputs |
|---|---|
| - start and destination point of the train unit<br>- wagon to be taken into account<br>- load particularity | - brake parameters + modification<br>- brake parameters + modification |

Allocated to:

- Train Preparation Staff

### 11.2.114 Close brake pipe cock

Description:

| |
|---|
| In this function, Train Preparation Staff closes the brake pipe cock after brake pipe test. |

| Inputs | Outputs |
|---|---|
| - leak noise | |

Allocated to:

- Train Preparation Staff

### 11.2.115 Open main pipe on last wagon

Description:

| |
|---|
| In this function, Train Preparation Staff opens the main pipe on the last wagon for the brake test, if train is equipped with a main pipe. |

Allocated to:

- Train Preparation Staff

### 11.2.116 Open brake pipe cock

Description:

| |
|---|
| In this function, Train Preparation Staff opens the brake pipe cock for the brake pipe test. |

Allocated to:

- Train Preparation Staff

### 11.2.117 Check shoes apply on wheel

Description:

In this function, Train Preparation Staff checks that brakes are effectively applied.

| Inputs | Outputs |
|---|---|
| - brake shoe position | - brake application OK |

Allocated to:

- Train Preparation Staff

### 11.2.118 Check shoes not apply on wheel

Description:

In this function, Train Preparation Staff checks that brakes are effectively released.

| Inputs | Outputs |
|---|---|
| - brake shoe position | - brake release ok |

Allocated to:

- Train Preparation Staff

### 11.2.119 Request locomotive wake-up

Description:

In this function, Train Preparation Staff requests the wake-up of a locomotive.

| Inputs | Outputs |
|---|---|
| | - request train wake-up |

Allocated to:

- Train Preparation Staff

### 11.2.120 Set train unit

Description:

| |
|---|
| In this function, Train Preparation Staff composes a freight train for a given mission. |

Allocated to:

- Train Preparation Staff

### 11.2.121 Request train hold

Description:

| |
|---|
| In this function, Train Preparation Staff requests the train immobilization by the system and informs when intervention on the train is finished. |

| Inputs | Outputs |
|---|---|
| | - train hold request<br>- end of intervention |

Allocated to:

- Train Preparation Staff

### 11.2.122 Release scotches

Description:

| |
|---|
| In this function, Train Preparation Staff removes scotches immobilizing wagons when necessary. |

Allocated to:

- Train Preparation Staff

### 11.2.123 Set scotches if necessary

Description:

| |
|---|
| In this function, Train Preparation Staff set scotches for immobilizing wagons when necessary. |

Allocated to:

- Train Preparation Staff

### 11.2.124 Check train immobilization

Description:

| |
|---|
| In this function, Train Preparation Staff checks train immobilization with the feedback of the headlights. |

| Inputs | Outputs |
|---|---|
| - information train immobilized | - information train immobilized<br>- information train immobilized |

Allocated to:

- Train Preparation Staff

### 11.2.125 Check-out/Check-in vehicle

Description:

| |
|---|
| In this function, TPS takes the responsibility of the train parked on a shunting yard:<br><br>- Train preparation activities can start when the intervention request is accepted by the system (train is then under TPS responsibility). Vehicle is checked-out.<br><br>- Responsibility is given back to the system when all conditions are satisfied (train is then under system responsibility). Vehicle is checked-in. |

| Inputs | Outputs |
|---|---|
| - train under TPS responsibility | - train under system responsibility<br>- intervention request |

Allocated to:

- Train Preparation Staff

### 11.2.126 Set/remove local protection for high voltage

Description:

| |
|---|
| In this function, the actor sets a local protection system on the train to forbid the use of high voltage or removes this protection. |

| Inputs | Outputs |
| --- | --- |
| | - cmd local protection OFF (staff)<br>- cmd local protection ON (staff) |

Allocated to:

- Train Preparation Staff

### 11.2.127 Realize cold weather operations

Description:

In this function, Train Preparation Staff intervenes on the train in case of winter conditions (ice on coupler for example).

Allocated to:

- Train Preparation Staff

### 11.2.128 Give visual and audible indication to passengers (in train)

Description:

This function elaborates travel information to passengers on-board the train.

| Inputs | Outputs |
| --- | --- |
| - cmd TIS OFF<br>- cmd TIS ON<br>- cmd_please_remove_obstacle_from_door<br>- cmd_some_doors_will_remain_locked<br>- cmd_do_not_open_the_door<br>- end of passenger service<br>- journey information<br>- coupling of train warning<br>- door opening parameters<br>- train departure time<br>- msg_ information_about_incident | - TIS status |

Allocated to:

- Transport Information System

## 11.3 Description of system functions

### 11.3.1 Determine/verify and transmit JP data

Description:

This function provides the Journey Profile (JP) for the train movements within allocated train path: departure times, arrival times, stations with or without stop. The function checks also JP consistency before transmission. The JP is linked to a specific task of the mission, it can be changed at any time without modifying this task (purpose is to have the most updated information). Changes can be requested to add or delete a station stop, when an itinerary is modified or in case of temporary constraint (additional speed restriction, low adhesion, ATO inhibition zone or DAS inhibition zone) .

Rationale: JP could be irrelevant if train cannot achieve 100% traction or braking capacity or if there is a new speed reduction on the track for example.

Note: if a train is not fully operational, a diagnostic should be provided at operational level (train maximum speed, maximum braking capacity, possible failure of some doors...) independently of the maintenance details. The estimated arrival time is very precise and can be used by TMS to update the JPs.

| Inputs | Outputs |
|---|---|
| - Journey Profile Request<br>- Journey Profile<br>- database update<br>- request for extended dwell time<br>- new stopping point | - Journey Profile<br>- request for extended dwell time<br>- Journey Profile Request |

Allocated to:

- ATO-AT

### 11.3.2 Determine/verify and transmit MP data

Description:

This function provides MP to ATO-AV after check of its consistency. It deals also with an empty task that was not updated in time. A request is transmitted to RU in order to receive a modification of mission.

Note: even if the concept of empty task is application specific, this need can be generalized to have a manual action in case of degraded situation and avoid a deadlock in operation.

| Inputs | Outputs |
|---|---|
| - request task addition<br>- on-going task number<br>- mission modification<br>- mission | - request task addition<br>- mission modification<br>- mission<br>- on-going task number |

Allocated to:

- ATO-AT

### 11.3.3 Manage ATO connections

Description:

This function manages the communication session with ATO-AV and transmits the ATO identity record for single or multiple units. The identity record is composed of:

- Single unit / multiple unit status

- ATO number and version of related software (M_ATO_version)

- Vehicle number controlled by the ATO

- In case of multiple units, the number of each coupled ATO with the corresponding vehicle number and the composition sequence

- Operational train running number (NID_OPERATIONAL will be updated for each JP defined in the mission)

- Train Management number (RU Server address).

Note: A consist number can also be used but there should be a single relationship between a consist and the vehicle of the consist hosting ATO.

| Inputs | Outputs |
|---|---|
| - ATO identity record<br>- handshake request | - ATO identity record<br>- handshake acknowledgement |

Allocated to:

- ATO-AT

### 11.3.4 Receive anomalies in task or mission execution

Description:

| |
|---|
| This function receives the anomalies associated to a specific task or mission. |

| Inputs | Outputs |
|---|---|
| - task delay warning<br>- mission modification rejected<br>- task rejected | - mission modification rejected<br>- task rejected<br>- task delay warning |

Allocated to:

- ATO-AT

### 11.3.5 Receive status of safety related equipment

Description:

| |
|---|
| This function receives the status of train safety related equipment. This information is used by RU to validate the mission. |

| Inputs | Outputs |
|---|---|
| - ORD memory capacity<br>- light alarm signal status (specific)<br>- track to train radio equipment status (specific)<br>- infra database version number<br>- EB test time and status<br>- STM status | - status of safety related equipment |

Allocated to:

- ATO-AT

### 11.3.6 Receive status report

Description:

| |
|---|
| This function receives train location, train health status, current TCMS state of the train and requests a new Journey Profile to TMS when an anomaly is detected by the train:<br><br>- damage to pantograph or air suspension<br><br>- horn default<br><br>- the current JP does not contain a station or rescue point<br><br>- shunting circuit compensator default.<br><br>Note: the skip of a station by driver in GoA2 should be performed automatically by GoA34 in case of incident. A new JP is then expected. Crowd incidents at platform are avoided thanks to the crowd management system of TMS. |

| Inputs | Outputs |
|---|---|
| - train local protection status<br>- train health status<br>- ATO state<br>- driving anomalies<br>- misrouting detected<br>- grip/ground adhesion problem<br>- stopping anomalies<br>- train location + heading + speed | - Status Report<br>- Status Report |

Allocated to:

- ATO-AT

### 11.3.7 Transmit coupling authorization

Description:

| |
|---|
| This function transmits the coupling authorization to ATO. |

| Inputs | Outputs |
|---|---|
| - coupling authorization | - coupling authorization |

Allocated to:

- ATO-AT

### 11.3.8 Transmit incidents to TIS

Description:

| |
|---|
| This function transmits incidents to passengers via ATO-AV and Transport Information System. |

| Inputs | Outputs |
|---|---|
| - msg_ information_about_incident | - msg_ information_about_incident |

Allocated to:

- ATO-AT

### 11.3.9 Transmit TPS orders

Description:

| |
|---|
| This function transmits the orders of Train Preparation Staff to ATO-AV. |

| Inputs | Outputs |
|---|---|
| - request compression<br>- uncoupling OK<br>- request train wake-up<br>- apply brake request<br>- release brake request<br>- brake release OK<br>- electro-pneumatic brake test OK<br>- coupling OK<br>- request coupling | - request compression<br>- uncoupling OK<br>- request train wake-up<br>- electro-pneumatic brake test OK<br>- brake release OK<br>- release brake request<br>- apply brake request<br>- request coupling<br>- coupling OK |

Allocated to:

- ATO-AT

### 11.3.10 Transmit updated infrastructure database

Description:

| |
|---|
| This function transmits an update of the infrastructure database when requested by a train. |

| Inputs | Outputs |
|---|---|
| - request infra database update<br>- request infra database version number<br>- database update | - infra database update<br>- infra database version number |

Allocated to:

- ATO-AT

### 11.3.11 Supervise the departure of the train

Description:

| |
|---|
| This function enables the departure of the train under the following conditions:<br><br>- doors are closed and locked<br><br>- signalling authorizes departure<br><br>- train environment is safe<br><br>- train departure is not inhibited<br><br>- train is able to perform its journey (health status ok)<br><br>- time is departure time and dwell time has elapsed (see function 2.2.1)<br><br>- high voltage is authorized (local protection status).<br><br>Before departure, this function requests to maintain the train at standstill. When departure conditions are fulfilled, the function requests to release the holding brakes and informs the driving function in order to compute the next stopping location. |

| **Inputs** | **Outputs** |
|---|---|
| - door closure sequences OK<br>- surroundings OK<br>- train health status<br>- T_Departure_Seconds<br>- MA<br>- authorization to proceed<br>- start prohibited<br>- local protection ON/OFF | - departure authorization<br>- departure authorization<br>- departure is prohibited |

Allocated to:

- ATO-AV

### 11.3.12 Command headlights/dipped headlights

Description:

| |
|---|
| This function is optional and requests for switching off the headlights and switching on the dipped headlights when a train is detected running in opposite direction. After crossing, the function requests again the headlights (active during night and day).<br><br>Note 1: optionally, a GoA4 train could run with only dipped headlights (impact on sensors to be checked).<br><br>Note 2: passengers at platform or workers need to be aware of a train approach, dipped headlights are required (see TSI OPE). |

| **Inputs** | **Outputs** |
|---|---|
| - train or vehicle in opposite direction | - cmd headlights/dipped headlights |

Allocated to:

- ATO-AV

### 11.3.13 Select running direction

Description:

| |
|---|
| This function determines from the Journey Profile the scheduled direction of movement and based on that the cab / front end to be activated:<br><br>- it stores the last Q_SPDIR upon which the train arrived.<br>- it stores the train configuration upon arrival including which cab / front end was active.<br>- it compares the Q_SPDIR in the JP for departure with the JP from arrival. If it is equal, it activates the cab that was active upon arrival. If not, it activates the opposite cab.<br>- it commands TCMS to activate the cab that was determined to lead the train. |

| **Inputs** | **Outputs** |
|---|---|
| - movement heading<br>- train configuration<br>- train configuration<br>- train movement configuration | - train orientation<br>- train orientation |

Allocated to:

- ATO-AV

### 11.3.14 Determine dynamic brake test time and location

Description:

| |
|---|
| This optional function determines the time and location for requesting a dynamic brake test:<br><br>- sufficient distance to brake<br><br>- zero gradient<br><br>- train at maximum speed<br><br>- pressure overload removed. |

| Inputs | Outputs |
|---|---|
| - current speed<br>- dynamic brake test location | - cmd dynamic brake test |

Allocated to:

- ATO-AV

### 11.3.15 Deactivate vigilance

Description:

| |
|---|
| This function is required for trains equipped with a vigilance device. The function deactivates the vigilance system, if any, to avoid an emergency brake in GoA34 operation. In GoA12, the device is activated by the driver as usual. This function is not required for trains running only in GoA34. |

| Inputs | Outputs |
|---|---|
| | - vigilance inhibition<br>- vigilance inhibition |

Allocated to:

- ATO-AV

### 11.3.16 Manage mission

Description:

| |
|---|
| This function loads a mission or a change of mission, checks it and computes the awakening sequences of ATO and train to be ready on time. It defines the sequence of tasks to be executed (uncoupling, coupling, brake test, service retention, awakening and shutdown of train), monitors the correct sequencing and records data related to the different tasks.<br><br>If the train is moving, the function evaluates if the modification is related to the current task (request is rejected) or not (request is accepted). If the train is at standstill, the function authorizes the modification of mission.<br><br>If the mission includes an empty task, the train remains stopped until a new task is received.<br><br>The function gives an alert when a task planned in a time window is not done. Time window defines when a train preparation staff request can be accepted.<br><br>The function requests a service retention when a task is finished and:<br><br>- no task with a starting time is defined for the next 30 min.<br><br>- next task has a starting time window but no action is performed during the 30 min following the activation of this window.<br><br>Note: a change of mission is only required in particular circumstances (train degraded performance after a failure for example). If the mission modification is rejected, the RU has to stop the train before to send a new one.<br><br>Note: a change of Journey Profile is not a change of task i.e. it is authorized when train is moving.<br><br>Note: mission is loaded in master ATO and slave ATO(s). |

| **Inputs** | **Outputs** |
|---|---|
| - mission modification<br>- mission<br>- uncoupling sequence ended<br>- coupling sequence ended<br>- test brake ended<br>- end of movement<br>- TCMS in service retention mode<br>- TCMS in shutdown mode<br>- train awaken / powered<br>- TCMS in service retention mode<br>- TCMS in shutdown mode<br>- current speed<br>- location + trainset heading<br>- cmd battery protection mode | - on-going task number<br>- mission modification rejected<br>- wake-up time ATO<br>- cmd service retention mode<br>- cmd shutdown mode<br>- departure time<br>- request task addition<br>- task delay warning<br>- task rejected<br>- cmd train wake-up<br>- mission is finished or cancelled<br>- coupling request<br>- splitting request<br>- start uncoupling sequence<br>- request coupling<br>- brake test requested<br>- brake test parameters<br>- train movement configuration<br>- mission is available<br>- ATO in sleeping mode<br>- cmd service retention mode<br>- cmd shutdown mode<br>- train movement configuration<br>- cmd battery protection mode<br>- handover request |

<u>Allocated to:</u>

- ATO-AV

### 11.3.17 Start coupling

<u>Description:</u>

| |
|---|
| This function activates the train coupling process where an automatic coupling operation is foreseen in the mission.<br><br>ATO-AV will drive according to the braking curve computed by ETCS for coupling until coupling speed. It will switch TCMS to coupling mode at about 1 m/s. Coupling can be cancelled during the approach until about 5m from the target where it is still possible to stop the train.<br><br>After physical coupling, a new train inauguration is started by TCMS. |

| **Inputs** | **Outputs** |
|---|---|
| - coupling authorization<br>- holding brake status<br>- coupling request | - cmd_heat_coupler<br>- cmd open close trapdoor<br>- coupling of train warning<br>- coupling front location<br>- cmd driving mode |

Allocated to:

- ATO-AV

### 11.3.18 Update data of movements within allocated train path

Description:

| |
|---|
| This function updates the Journey Profile received from ATO-AT. If not available, it sends a request to obtain it. |

| Inputs | Outputs |
|---|---|
| - train movement configuration<br>- Journey Profile<br>- request for extended dwell time | - T_Departure_Seconds<br>- serviced stations and journey profile<br>- timing points and stopping points<br>- timing point<br>- timing point<br>- start/stop point of movement<br>- start/stop point of movement<br>- actual arrival time + x min<br>- Journey Profile<br>- sand inhibition zone<br>- Q_Low_Adhesion_Rate<br>- T_Departure_Seconds<br>- Journey Profile Request<br>- serviced stations and journey profile<br>- dwell time extended<br>- serviced stations and journey profile<br>- request for extended dwell time<br>- Stopping Point characteristics |

Allocated to:

- ATO-AV

### 11.3.19 Start splitting

Description:

| |
|---|
| This function activates the train uncoupling process where an automatic splitting operation is foreseen in the mission. |

| Inputs | Outputs |
|---|---|
| - splitting done<br>- splitting request | - relax coupler<br>- cmd splitting |

Allocated to:

- ATO-AV

#### 11.3.20 Determine ATO state

Description:

| |
|---|
| This function manages the transitions between ATO modes (see chapter 8.3). In case of multiple unit, each ATO has its state machine, only one unit can be the master.<br><br>The modes are associated to a GoA level context. The table described in SRS 5.1.1.1.5 shows the possible cases. A GoA4 train is not authorized to run in a GoA3 area without train attendant for example.<br><br>Note: GoA2 modes are re-used. |

| Inputs | Outputs |
|---|---|
| - wake-up command<br>- mission is finished or cancelled<br>- ATO engage button<br>- desk is open/closed<br>- ATO tests ok<br>- ATO in sleeping mode<br>- ATO status<br>- train speed = 0<br>- assisted driving status<br>- mission is available<br>- ATO in master mode<br>- ATO in slave mode<br>- TCMS mode<br>- ATO disengage button<br>- TBL control | - request ATO outputs deactivation<br>- Q_AD_MODE_REQUEST<br>- ATO state<br>- request ATO outputs activation<br>- ATO state |

Allocated to:

- ATO-AV

### 11.3.21 Define if ATO is master or slave

Description:

| |
|---|
| This function is associated to the ATO state machine and requests to switch from standby mode to:<br><br>- master mode if the unit is related to the head of the train<br><br>- slave mode in the other cases with a transmission of the coupled train parameters.<br><br>Note: ATO in slave mode has still to perform several functions (to be defined, environment monitoring for example). |

| Inputs | Outputs |
| --- | --- |
| - position within the multiple unit<br>- train inauguration | - ATO in master mode<br>- ATO in slave mode |

Allocated to:

- ATO-AV

### 11.3.22 Supervise ATO connection and wake-up

Description:

| |
| --- |
| This function is active in ATO sleeping mode and supervises the wake-up of ATO at recorded time or on request to receive mission and/or journey profile information:<br><br>- initialization<br><br>- opening of the communication with ATO-AT (unique number permits to know where the train is)<br><br>- opening of the communication with the other ATOs of the multiple unit, if any.<br><br>When finished, it requests the version number of the infrastructure database and updates the on-board data base if necessary.<br><br>When transmission is finished, it checks if a task is programmed for the next 30 min:<br><br>- if yes, it remains awakened.<br><br>- if no, it informs about the timing of next task and starts the sleeping sequence.<br><br>Rationale: ATO is powered only when necessary, a specific module is dedicated to its awakening for battery saving. |

| Inputs | Outputs |
|---|---|
| - wake-up time ATO<br>- ATO state<br>- NID_OPERATIONAL<br>- NID_ENGINE<br>- handshake acknowledgement<br>- handover request | - ATO identity record<br>- request infra database update<br>- ATO tests ok<br>- wake-up command<br>- ATO-ATO communication OK<br>- ATO identity card<br>- handshake request |

Allocated to:

- ATO-AV

### 11.3.23 Supervise train wake-up

Description:

This function is associated to the TCMS state machine and requests train awakening on demand of the Train Management or Driver or TPS in a time window planned in the mission. For TPS, the solution to implement the request is not defined (call, sensor...). If the request is not done in the planned time window, the train awakening is no more authorized and a delay is transmitted to the Train Management.

The function supervises the following activities (ATO-AV is powered-on):

- powering vehicle depending on its initial state, type of vehicle and the presence of a catenary or not

- powering of the sensors and verification of location

- powering auxiliaries and checking the light signal alarm.

The initial power supply information upon train power-up for electrical train can be managed in two different ways:

- TCMS continuously supervises the battery and automatically raises the pantograph to recharge the battery if necessary. When the pantograph is raised, either traction power system detects on its own what current type is feed through the contact line or TCMS remembers the last value

- In case the TCMS functions are not available or the train is completely powered down, ATO-AV or Train Adapter memorises the last traction system setting from the segment profile used upon

| |
|---|
| arrival at the parking position. In this case, ATO-AV or Train Adapter is also responsible to trigger the lift of the pantograph.<br><br>Note: Catenary is synonym of Overhead Contact Line (OCL). In UK some lines are still electrified with a third rail. Common term for OCL and third rail is Contact Line (CL). |

| **Inputs** | **Outputs** |
|---|---|
| - cmd train wake-up<br>- vehicle powered<br>- vehicle powered<br>- vehicle powered<br>- track parameters<br>- request train wake-up | - cmd power on train<br>- train awaken / powered<br>- cmd power on train<br>- cmd power on train<br>- power supply OK (specific)<br>- power supply OK (specific) |

Allocated to:

- ATO-AV

### 11.3.24 Provide unit position in the multiple unit

Description:

| |
|---|
| This function determines the position of a unit in a multiple unit (each unit shares this information with the other units). |

| **Inputs** | **Outputs** |
|---|---|
| - possible itineraries<br>- location + trainset heading<br>- ATO-ATO communication OK | - position within the multiple unit |

Allocated to:

- ATO-AV

### 11.3.25 Transmit driving anomalies

Description:

| |
|---|
| This function reports anomalies related to the train movement to ATO-AT. |

| Inputs | Outputs |
|---|---|
| - grip/ground adhesion problem<br>- grip/ground adhesion problem<br>- itinerary KO<br>- stopping anomalies | - driving anomalies<br>- misrouting detected<br>- grip/ground adhesion problem<br>- stopping anomalies |

Allocated to:

- ATO-AV

### 11.3.26 Transmit information to TIS

Description:

| |
|---|
| This function sends journey information to on-board passengers via the Transport Information System:<br><br>- train departure time<br><br>- journey information<br><br>- end of passenger service before to close the doors<br><br>- door opening parameters (side...)<br><br>- door information (remove obstacle from door, door remains locked, do not open)<br><br>- warning if train coupling<br><br>- information about incident.<br><br>Note: data are operator specific. |

| Inputs | Outputs |
|---|---|
| - actual arrival time + x min<br>- coupling of train warning<br>- msg to remove obstacle<br>- serviced stations and journey profile<br>- location + trainset heading<br>- msg_ information_about_incident<br>- door opening parameters<br>- cmd_some_doors_will_remain_locked<br>- cmd_do_not_open_the_door<br>- Stopping Point characteristics | - journey information<br>- end of passenger service<br>- cmd_please_remove_obstacle_from_door<br>- cmd_some_doors_will_remain_locked<br>- cmd_do_not_open_the_door<br>- coupling of train warning<br>- door opening parameters<br>- train departure time<br>- msg_ information_about_incident |

Allocated to:

- ATO-AV

#### 11.3.27 Collect status of safety related equipment

Description:

| |
|---|
| This function collects information from safety related equipment to be transmitted for record and check that they are compatible with the elaboration of mission. For example, a failure of STM will impact the corresponding countries defined in the mission. |

| Inputs | Outputs |
|---|---|
| - infra database version number<br>- ORD memory capacity<br>- track-to-train radio equipment status (specific)<br>- light alarm signal status (specific)<br>- EB test time and status<br>- STM status | - ORD memory capacity<br>- light alarm signal status (specific)<br>- track to train radio equipment status (specific)<br>- infra database version number<br>- EB test time and status<br>- STM status |

Allocated to:

- ATO-AV

### 11.3.28 Transmit periodically train location

Description:

| |
|---|
| This function transmits periodically train location with the estimated time in seconds to arrive at the TP to ATO-AT (ATO status report). |

| Inputs | Outputs |
|---|---|
| - location + trainset heading | - train location + heading + speed |

Allocated to:

- ATO-AV

### 11.3.29 Calculate speed curve with incidents

Description:

| |
|---|
| This function computes the speed curve related to indications given by IPM (full service brake, service brake to rescue point, service brake to slow down). |

| Inputs | Outputs |
|---|---|
| - sensor efficiency distance<br>- full service brake<br>- itinerary KO<br>- service brake to slow down<br>- service brake to rescue point<br>- rescue point | - speed curve for incident<br>- rescue point request |

Allocated to:

- ATO-AV

### 11.3.30 Determine traction and deceleration capabilities

Description:

| |
|---|
| This function determines the traction and deceleration capacities of the vehicle based on the train composition and the health status of this train:<br><br>- braking data for a freight train: mass on the rail, obtained braked weight, train length and |

braking abacus of the loco

- multiple unit parameters for a passenger train (single unit or multiple units) The deceleration capacities are computed for service braking and emergency braking.

Note: subset-125 function.

| Inputs | Outputs |
|---|---|
| - obtained braked weight<br>- mass on the rail<br>- braking capacity<br>- braking capacity<br>- mass on the rail<br>- train length<br>- obtained braked weight<br>- train health status<br>- train length<br>- wagon type - characteristics<br>- wagon type - characteristics | - EB deceleration capacity<br>- SB deceleration capacity<br>- traction capacity<br>- traction capacity<br>- traction and deceleration capacity |

Allocated to:

- ATO-AV

### 11.3.31 Determine maximum authorised speed

Description:

This function computes the maximum speed curve applicable to the train (maximum speed without warning activation) based on the train location, the deceleration capacity of the train, the maximum speed profile, the gradient profile, the train category (maximum speed authorized for this train) and the maximum speed authorized by the environmental constraints, if any.

Behavior of GoA34 on the service tracks has to be defined (GoA2 is only active in FS mode).

Note: subset-125 function + interface with «Calculate speed curve due to incidents»

| Inputs | Outputs |
|---|---|
| - location + trainset heading<br>- speed curve for incident<br>- ETCS_ATO_Dynamic<br>- track parameters<br>- EB deceleration capacity<br>- train length<br>- train category<br>- speed restriction<br>- train length<br>- train category<br>- maximum train speed<br>- speed limitation | - max speed applicable curve |

Allocated to:

- ATO-AV

### 11.3.32 Optimize the consumption

Description:

| |
|---|
| This function optimizes driving and braking strategy in order to run the train as energy efficient as possible while respecting the intended timings and the infrastructure constraints:<br><br>- maximize coasting<br><br>- compute an energy efficient trajectory (e.g. kinetic energy vs slopes, wind effects)<br><br>- reduce traction power in case of lower catenary voltage<br><br>- anticipate increasing of voltage in approach of a power station (referenced in Digital Map)<br><br>- provide the maximum power parameters for regulation<br><br>- estimate the power offtake and regeneration (for trains with regenerative brakes)<br><br>- exchange expected power offtake and regeneration with ATO-AT.<br><br>This strategy could be refined later to take into account specific energy or power requests from |

| |
|---|
| Energy Manager keeping in mind that priority is given to punctuality (saving energy is possible when margin is available).<br><br>At this stage, the allowed current consumption is defined by M_CURRENT and ATO has to respect these limitations. For TMS, it gives the possibility to manage conflicts (a freight train requesting maximum power could lead to an absence of power for a second one for example).<br><br>It is also assumed that TCMS is able to optimize the energy consumption of the vehicle systems:<br><br>- maximize consumption of HVAC during regenerative braking; minimize consumption of HVAC during acceleration<br><br>- use efficiently the on-board energy storage devices (store energy during regenerative braking; deliver energy to support acceleration).<br><br>Note: subset-125 function. |

| **Inputs** | **Outputs** |
|---|---|
| - reference curve<br>- catenary voltage<br>- request coasting<br>- location + trainset heading | - optimized speed curve<br>- maximum power parameters |

Allocated to:

- ATO-AV

### 11.3.33 Respect JP Timing Points

Description:

| |
|---|
| This function provides the reference curve to be applied for respecting the Timing Points of the Journey Profile:<br><br>- Timing Points provided for line regulation<br><br>- Timing Points provided for line operation: passenger exchange or technical service (change of driver for example). |

| Inputs | Outputs |
|---|---|
| - timing point<br>- SB deceleration capacity<br>- max speed applicable curve<br>- Q_Low_Adhesion_Rate<br>- possible itineraries<br>- location + trainset heading<br>- traction capacity | - reference curve |

Allocated to:

- ATO-AV

### 11.3.34 Stop exactly at the intended location

Description:

This function finalizes the computation of the optimized target speed curve for regulation.

It is possible to define two stopping points with one Timing Point for stop and one Timing Point for departure to manage crowd issues.

| Inputs | Outputs |
|---|---|
| - departure authorization<br>- Stopping Point<br>- optimized speed curve<br>- trainset / wagons parked on the track<br>- new stopping point | - target speed curve<br>- Stopping Point<br>- target speed curve |

Allocated to:

- ATO-AV

### 11.3.35 Adapt dynamic train behavior

Description:

| |
|---|
| This function adapts the traction/braking model of the train if there is a difference of behavior between measurements and expectations. |

| **Inputs** | **Outputs** |
|---|---|
| - expected traction force<br>- measured traction force<br>- expected braking<br>- measured brake force<br>- dynamic test<br>- traction and deceleration capacity | - abacus correction<br>- abacus correction |

Allocated to:

- ATO-AV

### 11.3.36 Give current time

Description:

| |
|---|
| This technical function provides the UTC time to all ATO-AV functions. |

| **Inputs** | **Outputs** |
|---|---|
| - UTC time | |

Allocated to:

- ATO-AV

### 11.3.37 Give current protection state

Description:

| |
|---|
| This function gives the status of the local protection put by Train Preparation Staff in case of high voltage. If present, train departure is inhibited. The status of the local protection is sent for recording. |

| Inputs | Outputs |
|---|---|
| - local protection status | - train local protection status<br>- local protection ON/OFF |

Allocated to:

- ATO-AV

### 11.3.38 Control initial traction effort

Description:

| |
|---|
| This function controls initial traction effort of a loco according to the expected traction force. |

| Inputs | Outputs |
|---|---|
| - ad hoc brake released<br>- expected traction force<br>- traction capacity | - cmd traction force |

Allocated to:

- ATO-AV

### 11.3.39 Isolate/engage ATO outputs

Description:

| |
|---|
| This function isolates the ATO outputs in order that the local or remote driver can control the train (traction and braking commands). In GoA3, the function isolates the ATO outputs related to the doors. |

| Inputs | Outputs |
|---|---|
| - request ATO outputs deactivation<br>- request ATO outputs activation | - ATO status |

Allocated to:

- ATO-AV

### 11.3.40 Maintain train immobilization

Description:

| |
|---|
| This function ensures that the train remains at standstill when it is stopped at the intended location. The function requests holding brake until train departure. Holding brake release is done by TCMS as soon as traction is applied. |

| Inputs | Outputs |
|---|---|
| - train speed = 0<br>- departure is prohibited<br>- holding brake status<br>- departure authorization<br>- holding brake status<br>- target speed curve | - holding brake request<br>- holding brake status<br>- holding brake status<br>- holding brake release<br>- cmd_do_not_open_the_door<br>- holding brake status<br>- holding brake release<br>- holding brake request |

Allocated to:

- ATO-AV

### 11.3.41 Regulate traction and brake in distance

Description:

| |
|---|
| This function regulates traction and brakes according to the distance between loco and wagons or the compression request. |

| Inputs | Outputs |
|---|---|
| - coupler compression<br>- request coupling<br>- request compression (2)<br>- request compression (1)<br>- measured traction force | - cmd brake for accurate stop<br>- cmd accurate traction force |

Allocated to:

- ATO-AV

### 11.3.42 Control coupler relaxing effort

Description:

| |
|---|
| This function controls the brake pressure to release the automatic coupler. |

| Inputs | Outputs |
|---|---|
| - relax coupler | - brake pressure |

Allocated to:

- ATO-AV

### 11.3.43 Start door closing sequence

Description:

This function is train dependent and starts the door closing sequence when dwell time has elapsed and transfer of passengers is completed. When the passenger service is finished, it starts the door closing sequence a configurable timer after train stop (example: 10 min) and after confirmation that passengers are no more present in the train.

Journey Profile gives the minimum service to be guaranteed (T_Minimum_Dwell_Time). If an operator wants to reduce this dwell time in particular circumstances, it can be put to 0 (doors are not opened).

Different mechanisms can be used to modify the normal door closing sequence (TCMS must deal with these different requests with an associated priority):

- A key can be inserted in the door system to keep it open until the key is removed by local staff (PRM operation, door problem)
- Train can be hold longer than planned with a modified JP
- An incident must be reported to IPM if the door closing fails in order to decide the right reaction (new closing command after a while for example)
- RU or IM can decide to force the door closing in case of crowd (door closing is under the responsibility of RU unless RU and IM are an integrated entity). A direct C48 interface could be used for a remote control for example.

Note: This function is not safety related (TCMS will not authorize departure if doors are open).

Assumption: Train is equipped with an intelligent door system, designed to minimize injuries.

| Inputs | Outputs |
|---|---|
| - doors status = closed and locked<br>- absence of passengers in the train<br>- authorization to close the doors<br>- dwell time extended<br>- door closure forced<br>- T_Departure_Seconds<br>- doors status = closed and locked | - door closure sequences OK<br>- door close request<br>- request for extended dwell time<br>- door close request |

Allocated to:

- ATO-AV

### 11.3.44 Authorize the release of the doors

Description:

This function is train dependent and compares the current time with the departure time defined in the task and authorizes the release of the doors a configurable time before (example: 20 min) when the train is at standstill and holding brakes are applied.

The function determines the door opening parameters from the Journey Profile:

- Q_Opening_Door_Side specifying if ATO-AV has to manage the train doors opening and on which side the passenger exchange doors have to be opened.

- Q_Centralised_Opening defining if the doors are to be opened centralized or by the passengers.

These parameters are transmitted to:

- TIS for informing passengers of the door opening side.

- Door systems for determining the doors that will receive the release authorization (safety related information is provided by ETCS).

| Inputs | Outputs |
|---|---|
| - travelling direction 1 or 2<br>- holding brake status<br>- door status = open<br>- doors status = released<br>- location + trainset heading<br>- Stopping Point<br>- train parameters<br>- departure time<br>- door status = open<br>- doors status = released<br>- NID_SP and D_sending_position/direction<br>- Journey Profile<br>- train parameters<br>- train speed = standstill<br>- platform characteristics | - door open request<br>- door enable request<br>- cmd_some_doors_will_remain_locked<br>- stopping anomalies<br>- door open request<br>- door enable request<br>- door opening parameters<br>- door opening parameters |

Allocated to:

- ATO-AV

### 11.3.45 Calculate expected traction effort

Description:

| |
|---|
| This function computes the expected traction force according to train composition, gradient, climatic conditions and type of locomotive when traction is applied. The feedback loop permits to control traction efficiency and to adjust parameters if necessary. |

| Inputs | Outputs |
|---|---|
| - abacus correction<br>- track parameters | - expected traction force<br>- expected traction force |

Allocated to:

- ATO-AV

### 11.3.46 Calculate expected braking effort

Description:

| |
|---|
| This function computes the expected behavior of the train when a dynamic test is applied. |

| Inputs | Outputs |
|---|---|
| - abacus correction<br>- track parameters | - expected braking |

Allocated to:

- ATO-AV

### 11.3.47 Define brake sequence to apply

Description:

| |
|---|
| This function defines the brake test sequence and the braking regime to apply with the support of train preparation staff.<br><br>- for a locomotive without wagons, the adapter function 2.3.10 will supervise the test sequence.<br><br>- for a locomotive with wagons, the adapter function 2.3.9 will supervise the sequence.<br><br>The release of the brakes is supervised by the adapter function 2.2.23. |

| Inputs | Outputs |
|---|---|
| - brake test parameters<br>- brake test requested<br>- apply brake request<br>- release brake request<br>- brake release OK<br>- electro-pneumatic brake test OK<br>- train composition and brake capacity data<br>- train composition and brake capacity data | - request brake test sequence after coupling<br>- request brake test sequence without coupling<br>- braking regime<br>- test brake ended<br>- request brake test sequence after coupling<br>- request brake test sequence without coupling<br>- request brake release sequence<br>- request brake release sequence<br>- braking regime |

Allocated to:

- ATO-AV

### 11.3.48 Provide juridical data

Description:

| |
|---|
| This function provides juridical data to On-board Recording Device (ORD). The function checks also On-board Recording Device (ORD) settings:<br><br>- initialization of the communication<br><br>- memory capacity (not full). |

| Inputs | Outputs |
|---|---|
| - ATO identity card<br>- timing points and stopping points<br>- memory capacity | - juridical data<br>- ORD memory capacity<br>- initiate ORD exchange |

Allocated to:

- ATO-AV

### 11.3.49 Provide Train Protection parameters

Description:

| |
|---|
| This function provides required settings to Train Protection/ETCS.<br><br>Note: These data and their storage are safety related. Existing procedure with driver must be replaced with something clever (information through C19, interface with IPM-ISM which is outside the scope of GoA34). Current allocation to ATO-AV is not yet frozen. |

| **Inputs** | **Outputs** |
|---|---|
| | - ATP parameters<br>- ATP parameters validated |

Allocated to:

- ATO-AV

### 11.3.50 Monitor health status of the train

Description:

| |
|---|
| This function modifies the train performance parameters according to the train status. Functions isolated in TCMS or TIS can impose a speed restriction or a change of train characteristics (change of pantograph for example).<br><br>This function provides the health status of the train in order to decide if the train is still able to perform its mission or not. Outputs are restricted to operational limitations (detailed diagnosis is part of TCMS and transmitted through C48).<br><br>The operational restrictions currently identified are:<br><br>- Door failure (impact on dwell time)<br><br>- Pantograph failure<br><br>- Gauge limitation<br><br>- Number of bogies for traction and braking (compared to the nominal case)<br><br>- Fluid level for non-electric engines (impact on mission duration)<br><br>- STM failure (impact on countries defined in the mission) |

- Unit failure in a multiple unit configuration.

Note: The transmission of the expected arrival time in GoA2 permits RU to anticipate an operational problem but an explicit reporting of incident detected by TCMS has the advantage to check earlier if a mission must be stopped or not (a mission could continue until a border in case of STM failure for example).

| **Inputs** | **Outputs** |
|---|---|
| - air suspension isolated | - train health status |
| - pantograph restriction | - train health status |
| - door restriction | - speed restriction |
| - axle restriction | - train health status |
| - horn disturbed | - train health status |
| - main battery no more charging | |
| - degraded traction capacity | |
| - degraded braking capacity | |
| - fluid level for non-electric engines | |
| - train consist failure | |
| - potential trackside train detection problem | |

Allocated to:

- ATO-AV

### 11.3.51 Regulate traction and braking effort

Description:

This function regulates traction and brakes (pneumatic brakes or electric brakes) depending on regulation parameters when immobilization brake is not activated. The target speed curve is derived from the optimized speed curve. The passenger comfort is also taken into account.

This GoA2 function shall take into account the following information from the JP and SPs affecting the Traction or Brake effort limits in order to compute the traction/braking commands: low adhesion areas, allowed current consumption, powerless sections, switch off Regenerative Brake areas, switch off eddy current brake for service brake areas, switch off eddy current brake

| |
|---|
| for emergency brake areas, switch off Magnetic Shoe Brake areas. |

| Inputs | Outputs |
|---|---|
| - holding brake status<br>- measured traction force<br>- target speed curve<br>- measured brake force<br>- maximum power parameters<br>- track parameters<br>- train health status<br>- current speed | - cmd traction force<br>- cmd brake during itinerary |

Allocated to:

- ATO-AV

### 11.3.52 Supervise manual coupling sequence

Description:

| |
|---|
| This function supervises the sequence of actions related to the manual coupling of wagons:<br><br>- move loco to wagons<br><br>- control compression of buffers<br><br>- loco immobilization<br><br>- opening of the brake pipe (0 bar).<br><br>This function requires actions from the shunting yard worker:<br><br>- after check of loco immobilization (parking brake lights must be ON), manual coupling<br><br>- transmit information that coupling is finished. |

| Inputs | Outputs |
|---|---|
| - coupling OK<br>- request coupling<br>- request coupling<br>- direct brake applied<br>- trainset / wagons parked on the track | - request coupling<br>- coupling sequence ended<br>- cmd direct brake release<br>- cmd direct brake application<br>- cmd brake pipe = 0 bar<br>- request compression (1) |

Allocated to:

- ATO-AV

### 11.3.53 Supervise manual uncoupling sequence

Description:

This function supervises the sequence of actions related to the manual uncoupling of wagons:

- release loco direct brakes (wagons remain braked)

- control compression of buffers (move loco to set of wagons to loose coupling)

- loco immobilization with direct brake.

This function requires actions from the shunting yard worker:

- after loco immobilization check (parking brake lights are ON), manual uncoupling

- transmit information that uncoupling is finished.

| Inputs | Outputs |
|---|---|
| - start uncoupling sequence<br>- request compression<br>- uncoupling OK<br>- direct brake applied | - request compression (2)<br>- uncoupling sequence ended<br>- cmd direct brake release<br>- cmd direct brake application |

Allocated to:

- ATO-AV

### 11.3.54 Supervise service brake efficiency during operation

Description:

| |
|---|
| This function is train dependent (to be configured) and supervises the sequence of actions for testing the service braking efficiency during operation:<br><br>- cut-out traction<br><br>- request a configurable brake pressure of X bar (0,5 bar for example) and compares train behavior with expected one: in case of difference, it modifies braking algorithm parameters.<br><br>- when finished, control the brake pipe pressure to normal.<br><br>Rationale: driver of a freight train tests occasionally the brakes.<br><br>Note: with ATO, the approach of each station provides a regular feedback on the service brake for passenger trains. |

| Inputs | Outputs |
|---|---|
| - cmd dynamic brake test | - msg_service_brake_not efficient<br>- cmd brake pressure = 0,5 bar<br>- cmd traction off<br>- cmd brake pipe = reference pressure<br>- dynamic test<br>- msg_service_brake_not efficient<br>- cmd traction off |

Allocated to:

- ATO-AV

### 11.3.55 Check ad hoc brake release

Description:

| |
|---|
| This function checks if the release of the train brakes is acceptable at a given location based on the following parameters (in a slope, it is expected that brake release must be progressive and combined with traction effort):<br><br>- train type |

| |
|---|
| - train length<br><br>- track gradient<br><br>- measured braking effort. |

| Inputs | Outputs |
|---|---|
| - location + trainset heading<br>- train length<br>- measured brake force<br>- train length | - ad hoc brake released |

Allocated to:

- ATO-AV

### 11.3.56 Supervise driving desk

Description:

| |
|---|
| This function detects if the driving desk is locked or unlocked.<br><br>When the driving desk is locked, the Traction Breaking Lever (TBL) is mechanically locked. The train can be driven in GoA4 or in GoA3 with a train attendant in charge of specific functions (traction and braking are excluded). An identification is required by the system to authorize the assisted mode.<br><br>When the driver desk is unlocked by the driver, the TBL is active and the train can be driven in GoA0/1/2. |

| Inputs | Outputs |
|---|---|
| - desk status | - desk is open/closed<br>- assisted driving status |

Allocated to:

- ATO-AV

### 11.3.57 Suppress sanding

Description:

| |
|---|
| This function assures that sanding is not used when the Train Unit is on a section where sanding is prohibited. It reads the sanding suppression sections contained in the Segment Profiles and compares them to the Train Unit current estimated front end and rear end, which are derived from front end and train length, to command the start or end of sanding suppression to TCMS.<br><br>Note: sanding suppression can be ignored by TCMS in specific emergency situations. |

| Inputs | Outputs |
|---|---|
| - sand inhibition zone | - sand suppression command<br>- sand suppression command |

Allocated to:

- ATO-AV

### 11.3.58 Calculate all possible itineraries

Description:

This function calculates all possible itineraries between the start and the stop point of a train movement configured with or without allocated path. The function extracts relevant information from infra database and records it.

The purpose is not to check all possible itineraries in track plan data (combinatorial explosion) but to refer to alternative operational paths defined from a departure station (preferred one + alternatives). Alternatives for a JP can be pre-defined because they are well known by routing and IM.

Examples:

- Stop at Bruxelles-Nord station (21 possible platforms but only 2 or 3 are valid from a given train)

- JP defined for a left line should also be valid for the right line (same timetable).

Rationale: ATO should be able to operate until the next stopping point if there is a communication problem. In GoA2, ATO is disengaged but there is a driver. In GoA34, disengagement should be avoided and alternative JPs could be defined with different stopping points unless communication is reliable enough.

| Inputs | Outputs |
|---|---|
| - timing point | - possible itineraries |
| - start/stop point of movement | - possible itineraries |
| - current speed | - possible itineraries |
| - serviced stations and journey profile | - itineraries ahead |
| - location + trainset heading | - possible itineraries |

Allocated to:

- ATO-AV

### 11.3.59 Detect that final stopping point has been reached

Description:

This function informs the task manager when the train has reached its final stopping point.

| Inputs | Outputs |
|---|---|
| - start/stop point of movement<br>- location+ trainset heading | - end of movement |

Allocated to:

- ATO-AV

### 11.3.60 Determine track on which the train is engaged and direction

Description:

This function determines the track on which the train is engaged and direction thanks to the knowledge of itineraries and train location.

The front of the train is given by the active cab, a forward movement will lead the train in this direction and a backward movement in the opposite direction.

| Inputs | Outputs |
|---|---|
| - location + trainset heading<br>- serviced stations and journey profile | - NID_SP and D_sending_position/direction<br>- track/ direction<br>- NID_SP and D_sending_position/direction |

Allocated to:

- ATO-AV

### 11.3.61 Determine stopping point relative to the platform

Description:

| |
|---|
| This function provides the estimation of the stopping point based on the train characteristics (single unit, multiple unit, freight train length). This point is optimized according to trackside configuration given in infra database (hollow, hump, pedestrian crossing...) for identified track and train configuration (position of doors, train length...).<br><br>For sidings and without info from infra database, the stopping point is determined by sensors.<br><br>In case of parking on a track already occupied, the stopping point is identical but sensors will detect an obstacle on the track and the train will stop between 1 and 3 m of this obstacle.<br><br>In case of coupling, the stopping point is identical but sensors ensure a continuous approach at low speed.<br><br>For nominal cases stopping point is provided by Journey Profile and Segment Profile, and this function is not triggered. |

| Inputs | Outputs |
|---|---|
| - track/ direction<br>- train composition<br>- platform characteristics<br>- coupling front location<br>- train composition<br>- train length | - Stopping Point |

Allocated to:

- ATO-AV

### 11.3.62 Determine movement direction

Description:

| |
|---|
| This function determines the train movement direction based on train location and possible routes on the track. The front of the train is given by the active cab, a forward movement will lead the train in this direction and a backward movement in the opposite direction.<br><br>Note: Even without driver, an active cab has to be defined in order to keep the same conventions than other GoA levels. |

| Inputs | Outputs |
|---|---|
| - possible itineraries<br>- location + trainset heading | - movement heading |

Allocated to:

- ATO-AV

### 11.3.63 Check and update the infrastructure data base (if necessary)

Description:

| |
|---|
| This function checks that infrastructure data stored onboard are up to date after wake-up. The function requests the version number of infrastructure database and compares it with the stored version. In case of discrepancy, the function requests an update of the database. |

| Inputs | Outputs |
|---|---|
| - request infra database update<br>- infra database update<br>- infra database version number | - infra database version number<br>- request infra database update<br>- request infra database version number<br>- infrastructure database |

Allocated to:

- ATO-AV

### 11.3.64 Detect misrouting

Description:

| |
|---|
| This function detects and reacts to misrouting before a switch is engaged.<br><br>Note: The misrouting detection can be done in several ways: speed reduction, signal information, blade position at limited speed, linking information like in ETCS etc. When a misrouting is detected, the system brakes the train until stop with service brake and send a status report and wait for up to date instructions (to be completed). |

| Inputs | Outputs |
|---|---|
| - BG list<br>- location + trainset heading<br>- possible itineraries | - itinerary KO<br>- itinerary KO |

Allocated to:

- ATO-AV

### 11.3.65 Determine next stopping point or rescue point

Description:

| |
|---|
| This function determines the best stopping point for the train in case of alarm, station or rescue point. |

| Inputs | Outputs |
|---|---|
| - NID_SP and D_sending_position/direction<br>- next stopping points or rescue points<br>- train composition<br>- itineraries ahead<br>- train composition<br>- rescue point request | - new stopping point<br>- new stopping point<br>- rescue point |

Allocated to:

- ATO-AV

### 11.3.66 Maintain train physically immobilized

Description:

| |
|---|
| This function is performed today by the driver or train attendant with the installation of scotches on the wheels.<br><br>For GoA3, this need is fulfilled with train attendant. For GoA4, this need is a constraint exported to TCMS (spring-loaded brakes for example). |

| Inputs | Outputs |
|---|---|
| - cmd_physical_immobilization<br>- cmd_remove_physical_immobilization | |

Allocated to:

- ATO-AV

### 11.3.67 Provide infrastructure database

Description:

| |
|---|
| This function records all information related to infrastructure in a database that can be shared between different users and updated with authorized access. This infrastructure register is called RINF. |

| Inputs | Outputs |
|---|---|
| - track anomaly confirmed<br>- track description<br>- maintenance area activated | - database update<br>- database update |

Allocated to:

- DMT

### 11.3.68 Provide vehicle database

Description:

| |
|---|
| This function records all information related to vehicles in a database that can be shared between different users and updated with authorized access. |

RU manages the vehicles planned for the missions and delivered by the Fleet Manager.

| Inputs | Outputs |
|---|---|
| - vehicle characteristics | - vehicle database |

Allocated to:

- DMT

### 11.3.69 Extract infrastructure database information

Description:

This function provides infrastructure information on request.

| Inputs | Outputs |
|---|---|
| - infrastructure database | - level crossing to run with caution speed<br>- horn activation locations<br>- platform characteristics<br>- track parameters<br>- dynamic brake test location<br>- platform characteristics<br>- next stopping points or rescue points<br>- track parameters<br>- track parameters<br>- track parameters<br>- track parameters<br>- track parameters<br>- track parameters<br>- lineside signal information<br>- switch information<br>- infrastructure objects<br>- point failure identified<br>- broken or buckled rail identified<br>- damage to catenary identified<br>- flooding identified<br>- level crossing to run with caution speed<br>- maintenance area activated |

Allocated to:

- DMO

### 11.3.70 Transmit supervision orders

Description:

| |
|---|
| This function transmits direct orders from IM to Train Control and autonomous train. |

| Inputs | Outputs |
|---|---|
| - authorization to proceed<br>- order_caution_speed+observation<br>- authorization to override<br>- speed_restriction_order<br>- cmd_request_immobilization<br>- battery protection request<br>- cmd_remove_immobilization<br>- cmd_ETCS_stop<br>- slippery zone<br>- authorization to close the doors<br>- cmd_ClassB_signal_closure<br>- start prohibited | - authorization to proceed<br>- cmd caution speed on a given distance<br>- cmd_physical_immobilization<br>- battery protection request<br>- override_process<br>- cmd_speed_restriction<br>- cmd_remove_physical_immobilization<br>- cmd_ETCS_order01<br>- cmd_ETCS_stop<br>- cmd_ETCS_order_05<br>- cmd_ETCS_order03<br>- cmd_ETCS_start<br>- slippery zone<br>- cmd_temporary_speed_restriction<br>- authorization to close the doors<br>- cmd_ClassB_signal_closure<br>- pantograph drop request<br>- start prohibited |

Allocated to:

- IPM-ISM

#### 11.3.71 Manage trackside incidents

Description:

This function interfaces with Operation Manager to manage trackside incidents reported by IPM-OB.

| Inputs | Outputs |
|---|---|
| - track anomaly<br>- surroundings anomalies<br>- local alarm needed | - track anomaly<br>- livestock wandering<br>- anomalies of train / tracks / persons dead or injured<br>- anomaly detected on crossing train<br>- new JP requested<br>- livestock wandering<br>- anomalies of train / tracks / persons dead or injured<br>- track anomaly<br>- local_alarm_raised |

Allocated to:

- IPM-ISM

### 11.3.72 Manage train incidents

Description:

| |
|---|
| This function interfaces with Operation Manager to manage train incidents reported by IPM-OB (EB application for example). |

| Inputs | Outputs |
|---|---|
| - train anomaly | - train anomaly<br>- de-energized section<br>- de-energized section<br>- train anomaly |

Allocated to:

- IPM-ISM

### 11.3.73 Define driving action depending on incident

Description:

| |
|---|
| This function defines the train behavior when an incident is detected.<br><br>The onboard reactions identified until now are: Emergency Brake, pantograph lowering, passenger information, horn, light alarm, Service Brake to slow down or stop at next safe location.<br><br>Note: the principle of subsidiarity requests that what could be done on-board shall be done autonomously. This mechanism simplifies the degraded modes. The second step is to inform trackside for further actions (temporary speed restriction for example). |

| Inputs | Outputs |
| --- | --- |

| | |
|---|---|
| - distance to obstacle + type<br>- current speed<br>- suspected derailment<br>- suspected breakage of coupling<br>- railway agent signal<br>- radio_alarm (specific)<br>- light alarm signal (specific)<br>- emergency stop by gesture (specific)<br>- HVAC failure<br>- hot box alarm<br>- fire on board<br>- inappropriate behaviour<br>- broken or buckled track<br>- broken or buckled track<br>- msg_flooding<br>- unusual movements<br>- EB brake failure<br>- broken window<br>- high_voltage_anomaly<br>- bad_current_collection<br>- msg_weather_parameters<br>- msg_service_brake_not efficient<br>- fire description<br>- alarm signal<br>- explosion (specific)<br>- interior light failure<br>- suspicious luggage<br>- pantograph alarm<br>- level crossing damage<br>- injury to a person | - emergency stop<br>- full service brake<br>- horn request<br>- service brake to slow down<br>- cmd emergency pantograph drop<br>- alert for dispatcher<br>- EB + cause<br>- service brake to rescue point<br>- obstacle MA |

| Inputs | Outputs |
| --- | --- |
| - suspension problem<br>- horn disturbed<br>- level crossing to run with caution speed<br>- flooding identified<br>- broken or buckled rail identified<br>- point failure identified<br>- damage to catenary identified<br>- presence of a maintenance area<br>- authorized persons on/near the track<br>- horn request | |

Allocated to:

- IPM-OB

### 11.3.74 Check if the surroundings (except signalling) oppose the departure

Description:

| |
| --- |
| This function checks if the information received from Perception does not inhibit the departure of the train:<br><br>- no agents on or along the track<br><br>- no vehicle on the track<br><br>- no anomaly on the track or catenary<br><br>- no emergency stop order by humans. |

| Inputs | Outputs |
| --- | --- |
| - catenary / track anomaly on the route<br>- authorized persons on/near the track<br>- trainset / wagons parked on the track<br>- emergency stop by gesture (specific) | - surroundings OK |

Allocated to:

- IPM-OB

### 11.3.75 Receive supervision orders

Description:

| |
|---|
| This function receives direct orders from IM, by means of IPM-ISM, and forwards them to the related functions. |

| Inputs | Outputs |
|---|---|
| - authorization to proceed<br>- cmd caution speed on a given distance<br>- battery protection request<br>- override_process<br>- cmd_speed_restriction<br>- authorization to close the doors<br>- pantograph drop request<br>- cmd_physical_immobilization<br>- cmd_remove_physical_immobilization<br>- start prohibited | - authorization to proceed<br>- caution speed on a given distance<br>- On sight speed until next MA (line side signal)<br>- battery protection request<br>- authorization to close the doors<br>- pantograph drop request<br>- cmd_physical_immobilization<br>- cmd_remove_physical_immobilization<br>- start prohibited<br>- cmd_speed_restriction |

Allocated to:

- IPM-OB

### 11.3.76 Transmit anomalies of the surroundings

Description:

| |
|---|
| This function reports anomalies related to train environment to IPM-ISM for analysis and decision. |

| Inputs | Outputs |
| --- | --- |
| - adjacent tracks anomalies<br>- detected obstacle + type<br>- msg_live_stock_wandering<br>- msg_anomalies_on_catenary<br>- msg_anomalies_of_adjacent_catenary<br>- rear light missing<br>- rear light missing<br>- front light missing<br>- front light missing<br>- broken or buckled track<br>- broken or buckled track<br>- msg_flooding<br>- msg_flooding (adjacent track)<br>- level crossing damage<br>- other crossing train anomalies<br>- sparks on a roof<br>- uncontrolled train detected<br>- anomalies in rear of the train<br>- anomalies on train sides<br>- injury to a person<br>- msg_body discovered<br>- msg_body discovered | - surroundings anomalies<br>- track anomaly |

Allocated to:

- IPM-OB

### 11.3.77 Transmit train incident report

Description:

This function reports vehicle incidents that can affect the safety of the passengers (air conditioning failure, interior lights...) for analysis and decision. RU is informed through the ground channel of TCMS via a dedicated message (interoperable and different from the

| |
|---|
| proprietary messages related to maintenance) and IM is informed through IPM trackside. |

| Inputs | Outputs |
|---|---|

| | |
|---|---|
| - bad_current_collection<br>- light alarm signal test result (specific)<br>- sensor efficiency distance<br>- suspected breakage of coupling<br>- GoA1-GoA2 non possible (specific)<br>- broken window<br>- TIS out of order<br>- suspicious luggage<br>- inappropriate behaviour<br>- door failure<br>- HVAC failure<br>- fire on board<br>- loss in fluid energy<br>- potential trackside train detection problem<br>- main battery no more charging<br>- suspension problem<br>- pantograph alarm<br>- EB brake failure<br>- high_voltage_anomaly<br>- msg_service_brake_not efficient<br>- EB + cause<br>- alarm signal<br>- EB_distance > Danger Point distance<br>- interior light failure<br>- suspected derailment<br>- hot box alarm<br>- horn disturbed<br>- unusual movements<br>- loss of headlights<br>- degraded braking capacity | - train anomaly |

| Inputs | Outputs |
|---|---|
| - degraded traction capacity | |

Allocated to:

- IPM-OB

### 11.3.78 Alarm all trains locally

Description:

| |
|---|
| This function informs IM of an incident that could impact other trains running in the same radio cell in order to stop them. |

| Inputs | Outputs |
|---|---|
| - alert for dispatcher | - local alarm needed |

Allocated to:

- IPM-OB

### 11.3.79 Map and monitor object

Description:

This function extracts information from infrastructure database based on train position. It informs also Perception that the train is approaching a specific object/area based on the train localization and the infrastructure database to avoid false alarms.

The function deals with the following objects:

- switch

- signal or marker board

- track parameters

- track information for traction effort and dynamic brake test

- next stopping point for a station with platform parameters and stopping point characteristics

- static infrastructure elements like bridge (to avoid a false alarm in obstacle detection)

- dynamic infrastructure elements like maintenance area or level crossing (to avoid a false alarm in obstacle detection).

| Inputs | Outputs |
|---|---|
| - infrastructure objects<br>- location + trainset heading<br>- point failure identified<br>- broken or buckled rail identified<br>- damage to catenary identified<br>- flooding identified<br>- level crossing to run with caution speed<br>- maintenance area activated | - area of interest<br>- presence of a maintenance area<br>- level crossing to run with caution speed<br>- broken or buckled rail identified<br>- damage to catenary identified<br>- point failure identified<br>- flooding identified<br>- area of interest |

Allocated to:

- IPM-OB

### 11.3.80 Monitor alarm signal

Description:

This function supervises the passenger alarms: call for help button and emergency request.

| Inputs | Outputs |
|---|---|
| - alarm signal | - alarm signal<br>- alarm signal |

Allocated to:

- IPM-OB

### 11.3.81 Monitor axle box temperature

Description:

This function reacts to an axle box alarm:

- for an alarm with danger, it triggers the Emergency Brake application.

- for an alarm without danger, it requests to stop the train at next station or rescue point. When the train is stopped, the function requests a movement at low speed to check with dedicated sensors if an axle is blocked or not.

| Inputs | Outputs |
| --- | --- |
| - hot box<br>- axle status | - hot box alarm<br>- axle inspection<br>- axle restriction<br>- hot box alarm |

Allocated to:

- IPM-OB

### 11.3.82 Monitor battery protection mode

Description:

This function monitors the battery power level and requests ATO to put TCMS in battery protection mode if level is too low or when requested by RU.

The function reports an alarm in case of battery charger default.

| Inputs | Outputs |
| --- | --- |
| - battery protection request<br>- msg_main_battery_power_level | - cmd battery protection mode<br>- main battery no more charging<br>- main battery no more charging |

Allocated to:

- IPM-OB

### 11.3.83 Monitor couplers

Description:

This function monitors brake pressure in order to detect a possible breakage of coupling (train anomaly).

Note: this function is not safety related and different from Train Integrity Monitoring System

| |
|---|
| developed for ETCS L3. |

| Inputs | Outputs |
|---|---|
| - sudden decrease of pressure | - suspected breakage of coupling<br>- suspected breakage of coupling |

Allocated to:

- IPM-OB

### 11.3.84 Monitor derailment

Description:

| |
|---|
| This function detects a bogie instability that could lead to a train derailment and triggers an emergency brake. |

| Inputs | Outputs |
|---|---|
| - bogie instability detected | - suspected derailment<br>- suspected derailment |

Allocated to:

- IPM-OB

### 11.3.85 Monitor doors incidents

Description:

| |
|---|
| This function monitors the door incidents (anomaly, obstacle during door closing). |

| Inputs | Outputs |
|---|---|
| - door failure<br>- obstacle | - door closure forced<br>- msg to remove obstacle<br>- door failure<br>- door restriction |

Allocated to:

- IPM-OB

### 11.3.86 Monitor EB distance to Danger Point

Description:

| |
|---|
| This function checks EB distance against distance to Danger Point and informs IM when this distance is longer. |

| Inputs | Outputs |
|---|---|
| - location + trainset heading<br>- next danger point | - EB_distance > Danger Point distance |

Allocated to:

- IPM-OB

### 11.3.87 Monitor fire alarm

Description:

| |
|---|
| This function reacts to fire detection and transmits a fire alarm. |

| Inputs | Outputs |
|---|---|
| - fire on board | - fire on board<br>- fire on board |

Allocated to:

- IPM-OB

### 11.3.88 Monitor loss of voltage or low voltage

Description:

| |
|---|
| This function monitors catenary voltage to detect a loss of voltage or a low voltage.<br><br>Rationale: SNCF operational rule where driver detects a loss of voltage, he must check it after 20s. |

| Inputs | Outputs |
|---|---|
| - high_voltage_anomaly | - catenary voltage<br>- request coasting<br>- high_voltage_anomaly<br>- high_voltage_anomaly |

Allocated to:

- IPM-OB

### 11.3.89 Monitor pantograph

Description:

This function detects and reports anomalies on the catenary (or other contact lines) that are so strong that they inhibit the train to run safely over it.

A pantograph problem shall be basically handled by the defined and standardized pantograph detection and protection system (see EN 50206-1, Automatic Dropping Device).

Rationale: specific trains with dedicated sensors are used for the detailed monitoring of track and catenary.

| Inputs | Outputs |
|---|---|
| - current gap detected<br>- pantograph problem | - bad_current_collection<br>- bad_current_collection<br>- pantograph restriction<br>- pantograph alarm<br>- pantograph alarm |

Allocated to:

- IPM-OB

### 11.3.90 Monitor shunting circuit compensator default

Description:

This function reports a positioning error in case of shunting circuit compensator default.

| Inputs | Outputs |
|---|---|
| - potential trackside train detection problem | - potential trackside train detection problem<br>- potential trackside train detection problem |

Allocated to:

- IPM-OB

### 11.3.91 Monitor suspension status

Description:

| |
|---|
| This function monitors the air suspension for reporting anomalies and possible isolation. |

| Inputs | Outputs |
|---|---|
| - suspension status | - suspension problem<br>- air suspension isolated<br>- suspension problem |

Allocated to:

- IPM-OB

### 11.3.92 Monitor TIS status

Description:

| |
|---|
| This function monitors the TIS status for reporting anomalies and possible isolation. |

| Inputs | Outputs |
|---|---|
| - TIS problem | - TIS out of order |

Allocated to:

- IPM-OB

### 11.3.93 Monitor train interior

Description:

This function monitors train interior and informs IM in the following cases:

- climate failure

- inappropriate behavior of passengers

- suspicious luggage

- broken window.

In case of inappropriate behavior, it requests to stop the train at next station or rescue point. In station, it applies emergency brakes to avoid a train departure.

In case of suspicious luggage or broken window, it requests to stop the train at next station or rescue point. For broken window, it can also be configured for a quicker reaction (Calculate speed curve due to incidents).

Monitoring of locomotive interior must also be considered, it is performed by the driver today (smell or noise for example).

| **Inputs** | **Outputs** |
|---|---|
| - unexpected passenger<br>- HVAC failure<br>- interior light failure<br>- broken window<br>- suspicious luggage<br>- inappropriate behavior | - inappropriate behaviour<br>- inappropriate behaviour<br>- suspicious luggage<br>- broken window<br>- broken window<br>- HVAC failure<br>- HVAC failure<br>- interior light failure<br>- suspicious luggage<br>- interior light failure<br>- absence of passengers in the train<br>- cmd_ventilation_without_energy |

Allocated to:

- IPM-OB

### 11.3.94 Monitor train unit failures

Description:

| |
|---|
| This function collects and combines the failures affecting a train unit that can have an impact on operation. A mission could be modified because of a train consist failure or a reduction of traction and braking capacity for example. |

| Inputs | Outputs |
|---|---|
| - EB brake failure<br>- loss in fluid energy<br>- horn disturbed<br>- loss of headlights<br>- degraded braking capacity<br>- degraded traction capacity<br>- train consist failure<br>- fluid level for non-electric engines | - EB brake failure<br>- EB brake failure<br>- loss in fluid energy<br>- degraded traction capacity<br>- degraded braking capacity<br>- fluid level for non-electric engines<br>- train consist failure<br>- horn disturbed<br>- horn disturbed<br>- loss of headlights<br>- horn disturbed<br>- degraded braking capacity<br>- degraded traction capacity |

Allocated to:

- IPM-OB

### 11.3.95 Monitor weather conditions

Description:

| |
|---|
| This function monitors weather conditions: temperature/percentage of water/wind.<br><br>Trackside weather forecasts are a starting point to derive driving restrictions from weather conditions. They do not cover local effects like ice, tornado or fog (possible impact on sensors).<br><br>As far as the local weather conditions can be refined (and the driving behaviour adapted |

accordingly) by sensors that are available on the train anyway, they can be used for this purpose. But dedicated weather sensors or weather measurement is not a mandatory feature of an autonomous train.

| **Inputs** | **Outputs** |
|---|---|
| - weather information | - msg_weather_parameters |

Allocated to:

- IPM-OB

### 11.3.96 Localize vehicle (track/direction/position/heading)

Description:

This function localizes the train on the infrastructure:

- track

- train direction on the track

- train position on the track

- train orientation on the track (roll, pitch, yaw).

| Inputs | Outputs |
|---|---|
| - train movement | - location + trainset heading<br>- location + trainset heading<br>- location + trainset heading<br>- location + trainset heading<br>- location + trainset heading<br>- location + trainset heading<br>- location + trainset heading<br>- location + trainset heading<br>- location + trainset heading<br>- location + trainset heading<br>- location + trainset heading<br>- location + trainset heading<br>- location + trainset heading (specific)<br>- location + trainset heading<br>- location + trainset heading<br>- location+ trainset heading<br>- location + trainset heading<br>- location + trainset heading<br>- location + trainset heading<br>- location + trainset heading<br>- location + trainset heading<br>- location + trainset heading<br>- location + trainset heading<br>- location + trainset heading |

Allocated to:

- Localization

### 11.3.97 Measure train speed

Description:

| This function measures train speed and provides current speed information (including standstill information). |
|---|

| Inputs | Outputs |
|---|---|
| | - current speed<br>- train speed = 0<br>- train speed = 0<br>- current speed<br>- current speed<br>- current speed<br>- train speed = standstill<br>- current speed<br>- current speed |

Allocated to:

- Localization

### 11.3.98 Provide UTC time

Description:

| This technical function provides UTC time received from GNSS receiver. |
|---|

| Inputs | Outputs |
|---|---|
| | - UTC time |

Allocated to:

- Localization

### 11.3.99 Record juridical data

Description:

| This function records juridical data in On-board Recording Device (ORD). |
|---|

| Inputs | Outputs |
|---|---|
| - initiate ORD exchange<br>- juridical data | - memory capacity |

Allocated to:

- ORD

### 11.3.100 Detect abnormal passenger behavior

Description:

| |
|---|
| This function is optional and detects a train interior anomaly, a passenger inappropriate behavior or a suspicious luggage.<br><br>Note: it could be an exported constraints to a modern TCMS (H.E.E Manage surveillance system). TCMS CCTV images are today not sufficient for detection of suspicious luggage for example. |

| Inputs | Outputs |
|---|---|
| - luggage in train<br>- passenger behavior | - suspicious luggage<br>- inappropriate behavior |

Allocated to:

- PER

### 11.3.101 Detect presence of passengers

Description:

| |
|---|
| This function detects a train interior anomaly, the presence of passengers inside the train at the end of a passenger service.<br><br>Note: it could be an exported constraints to a modern TCMS (H.E.E Manage surveillance system). |

| Inputs | Outputs |
|---|---|
| - passenger inside train | - unexpected passenger |

Allocated to:

- PER

### 11.3.102 Detect railway agents on or along the tracks

Description:

| |
|---|
| This function senses the Physical Railway Environment to detect the possible presence of railway agents on or along the tracks. Horn or a configurable reaction must be activated in case staff is not in the protection zone.<br><br>Note: maintenance area is currently not part of the Journey Profile. It is assumed that it could be transmitted via update of infrastructure database (to be confirmed). |

| Inputs | Outputs |
|---|---|
| - railway agent | - authorized persons on/near the track<br>- authorized persons on/near the track |

Allocated to:

- PER

### 11.3.103 Detect vehicle or buffer stop on the same track

Description:

| |
|---|
| This function senses the Physical Railway Environment to detect the possible presence of vehicles on the same track, every time Route Control cannot determine if free or not. It implies a precise measurement of the distance to vehicle during approach at low speed. This detection is also used for the approach of a buffer stop.<br><br>Note: This function is not requested for ATP. It is required by ATO for coupling/shunting/on-sight movements or dedicated situations at limited speed (limited parking space for example). This function should not be safety related. |

| Inputs | Outputs |
| --- | --- |
| - vehicle on track | - trainset / wagons parked on the track<br>- trainset / wagons parked on the track<br>- trainset / wagons parked on the track<br>- trainset / wagons parked on the track |

Allocated to:

- PER

### 11.3.104 Detect light failure on a train unit on the same track

Description:

This function is optional and senses the Physical Railway Environment to detect the possible presence of vehicles on the same track and check the status of their front or rear light.

| Inputs | Outputs |
| --- | --- |
| - vehicle on track | - rear light missing<br>- front light missing |

Allocated to:

- PER

### 11.3.105 Detect crossing train

Description:

This function monitors the train environment to detect the presence of a train running in the opposite direction on an adjacent track.

| Inputs | Outputs |
| --- | --- |
| - crossing train in approach | - train or vehicle in opposite direction<br>- horn request |

Allocated to:

- PER

### 11.3.106 Detect light failure on a crossing train unit

Description:

| |
|---|
| This function is optional and senses the Physical Railway Environment to detect the possible presence of vehicles on the opposite track and check the status of their front or rear light. |

| Inputs | Outputs |
|---|---|
| - crossing train anomalies | - rear light missing<br>- front light missing |

Allocated to:

- PER

### 11.3.107 Detect anomalies on crossing train

Description:

| |
|---|
| This function detects anomalies on a crossing train like an abnormal loading gauge or a wagon losing its cover for example.<br><br>The solution will depend on the maximum capacity of the mandatory sensors (sensors can offer more than expected in some cases), additional specific sensors could be used if not possible with the train front monitoring sensors. Specific trackside checkpoints are another solution. |

| Inputs | Outputs |
|---|---|
| - crossing train anomalies | - other crossing train anomalies |

Allocated to:

- PER

### 11.3.108 Detect uncontrolled crossing train

Description:

| |
|---|
| This function detects that a crossing train is moving without control like a wagon or coach moving by itself without loco or an EMU moving without pantograph when not in a lower pantograph section.<br><br>Note: another solution could be to give to the system a location where the train is expected to |

| |
|---|
| cross a train at a certain speed  with an alarm if an anomaly is detected. |

| Inputs | Outputs |
|---|---|
| - uncontrolled train | - uncontrolled train detected |

Allocated to:

- PER

### 11.3.109 Detect person struck by train

Description:

| |
|---|
| This function monitors the train environment in order to detect a person struck by the train. The person should be detected before hit. This trigger permits to record relevant information for further legal investigation. |

| Inputs | Outputs |
|---|---|
| - strucked person | - injury to a person<br>- injury to a person |

Allocated to:

- PER

### 11.3.110 Detect abnormal noises and vibrations on the train

Description:

| |
|---|
| This function monitors the train environment (car body and roof) to detect abnormal noises.<br><br>The detection should be based on shock/noise and not camera. The size of a block falling from a bridge is too small for normal detection for example. Another example is a level of snow too high that can be detected by increased noise when running.<br><br>Driver contacts IM today for action (slow down in some cases or check at next station sometime). Reporting of such event is thus required in GoA34. |

| Inputs | Outputs |
|---|---|
| - abnormal noise | - abnormal noise on the car body<br>- unusual impact |

Allocated to:

- PER

### 11.3.111 Detect sparks on a train roof

Description:

This function is optional and reports a traction problem on a crossing train when it detects abnormal sparks on its roof. This function is a particular case of «Monitor conditions of adjacent tracks and catenaries» function.

Note: modern trains have already a pantograph monitoring function with the possibility to switch to a second pantograph when a problem is detected on the first pantograph.

| Inputs | Outputs |
|---|---|
| - sparks on a roof | - sparks on a roof |

Allocated to:

- PER

### 11.3.112 Monitor conditions of adjacent tracks and catenaries

Description:

This function monitors the train environment (adjacent tracks and catenaries) to detect anomalies on infrastructure:

- obstacle on adjacent track

- catenary problem

The function is informed of the location of infrastructure elements to avoid false alarms.

Today, a driver sees all tracks in sight range when leaving a station and can report an incident. The requirements associated to view angles and distances are different between an adjacent track and the current track associated to obstacle detection. Target is to avoid trackside equipment as much as possible, a full coverage by trackside CCTV camera would be expensive.

| |
|---|
| Different requirements could imply different sensors for the running direction and the opposite direction, a feedback from the test tracks is necessary. |

| **Inputs** | **Outputs** |
|---|---|
| - area of interest<br>- flooding (adjacent track)<br>- track anomaly (adjacent track)<br>- catenary anomaly (adjacent track)<br>- body discovered | - adjacent tracks anomalies<br>- msg_anomalies_of_adjacent_catenary<br>- broken or buckled track<br>- broken or buckled track<br>- msg_flooding (adjacent track)<br>- msg_body discovered |

Allocated to:

- PER

### 11.3.113 Monitor condition of current track and catenary

Description:

| |
|---|
| This function senses the Physical Railway Environment to monitor the track and the catenary used by the train to detect infrastructure anomalies. This function is not foreseen for infrastructure maintenance because there are dedicated trains for that but maintenance information can be reported if available. |

| **Inputs** | **Outputs** |
|---|---|
| - flooding<br>- track anomaly<br>- live stock wandering<br>- catenary anomaly<br>- body discovered<br>- area of interest | - catenary / track anomaly on the route<br>- catenary / track anomaly on the route<br>- msg_live_stock_wandering<br>- msg_anomalies_on_catenary<br>- broken or buckled track<br>- broken or buckled track<br>- msg_flooding<br>- msg_flooding<br>- msg_body discovered |

Allocated to:

- PER

### 11.3.114 Detect fire or heavy smoke on embankment

Description:

| |
|---|
| This function detects fire or heavy smoke on embankment and provides a fire description to initiate a reaction. |

| Inputs | Outputs |
|---|---|
| - external fire | - fire description |

Allocated to:

- PER

### 11.3.115 Detect hand signal or red light flare

Description:

| |
|---|
| This function detects emergencies communicated by railway agents with a hand signal or a red light flare.<br><br>This function is required in case of mixed traffic but other means can be investigated. |

| Inputs | Outputs |
|---|---|
| - railway agent signal | - railway agent signal |

Allocated to:

- PER

### 11.3.116 Detect level crossing damage

Description:

| |
|---|
| This function detects failures on a level crossing (broken barrier for example).<br><br>Level crossing object is in DMO and can be completed with a caution speed attribute until repair. |

| Inputs | Outputs |
|---|---|
| - level crossing damage | - level crossing damage<br>- level crossing damage |

Allocated to:

- PER

### 11.3.117 Detect unusual movements

Description:

| |
|---|
| This function detects unusual lateral or vertical movements of the train body that could be caused by track defaults, objects on the track or strong lateral wind in the case of high speed trains. Incident must be transmitted through IPM.<br><br>This function is different from «Detect abnormal noises and vibrations on the train» and «J.B.C Provide derailment information».<br><br>Note: it should be a TCMS function causing a speed reduction (to be checked with Connecta) however it remains currently allocated to PER because there will be an operational issue if the things perceived today by the driver are not implemented in TCMS. It could lead to a duplication of the function like for example roll away currently implemented in ETCS and TCMS. |

| Inputs | Outputs |
|---|---|
| - train body dynamic | - unusual movements<br>- unusual movements |

Allocated to:

- PER

### 11.3.118 Identify an obstacle downstream or already encountered

Description:

| |
|---|
| This core function monitors the train environment (downstream) to detect these possible events:<br><br>- anomaly on the track or catenary<br><br>- abnormal noise on the car body |

- injury to a person

- trainset or wagons on track.

The function reports the type of obstacle detected and the distance to this obstacle. The case of an obstacle that has disappeared from Perception but is still present under the train must be considered.

The following obstacles are currently identified:

- Tree/rocks/landslide/flooding and unknown with minimum volume like fridge or tv must be detected. Smaller objects should be ejected from the track by Rolling Stock protections.

- Buffer stop object must be detected by PER, its location is part of DMO and approach will be similar to coupling approach.

Detailed implementation must be refined, the decision if obstacle is in the train trajectory or not should be in IPM.

| Inputs | Outputs |
|---|---|
| - catenary / track anomaly on the route<br>- abnormal noise on the car body<br>- trainset / wagons parked on the track<br>- unusual impact | - distance to obstacle + type<br>- detected obstacle + type |

Allocated to:

- PER

### 11.3.119 Check hot box

Description:

This function deals with hot box alarm verification (specific sensor for the detection of an axle movement at low speed).

| Inputs | Outputs |
|---|---|
| - axle inspection<br>- axle rotation at low speed | - axle status |

Allocated to:

- PER

### 11.3.120 Detect incident on train sides

Description:

This function deals with incidents identified by specific sensors around the train like a train attendant should do in GoA3.

| Inputs | Outputs |
|---|---|
| - train side anomaly | - anomalies on train sides |

Allocated to:

- PER

### 11.3.121 Detect incident on train rear

Description:

This function deals with incidents identified by a rear camera (catenary damage caused by the train for example).

If rear-end-perception is used (optional), the same standardized incident catalogue is used as for front end perception. If rear-end perception detects an incident, this is sent to trackside in the same incident report format as for front perception but flagged as rear-end incident.

| Inputs | Outputs |
|---|---|
| - incident caused by the train | - anomalies in rear of the train |

Allocated to:

- PER

### 11.3.122 Measure coupler compression

Description:

| |
|---|
| This function measures the compression of the coupler between loco and wagon for freight coupling or uncoupling operation. |

| Inputs | Outputs |
|---|---|
| | - coupler compression |

Allocated to:

- PER

### 11.3.123 Measure sensor efficiency distance

Description:

| |
|---|
| This technical function monitors the PER sensors that can fail (not compatible with GoA4 operation) or have degraded performance. A self-test function is required to evaluate the distance of efficiency of these sensors. This distance could depend on the environmental conditions (rain, fog, night, snow,...).<br><br>Today, the driver runs in cab signalling with full speed in case of fog but a radar could lead to another reaction like a slow down if its efficiency is reduced for example. |

| Inputs | Outputs |
|---|---|
| | - sensor efficiency distance<br>- sensor efficiency distance |

Allocated to:

- PER

### 11.3.124 Stream video data

Description:

| |
|---|
| This function gives access to rough images from PER front module. It is a technical function not used by a UC today, it is an available option. |

| Inputs | Outputs |
|---|---|
| - video stream request | - video stream |

Allocated to:

- PER

### 11.3.125 Open/Close signals

Description:

| |
|---|
| This function controls the lineside signalling state. |

| Inputs | Outputs |
|---|---|
| - route setting<br>- cmd_ClassB_signal_closure | - lineside signalling state<br>- signalling states |

Allocated to:

- Route Control

### 11.3.126 Convert signalling information

Description:

| |
|---|
| This function converts national signalling information into ETCS information.<br><br>Note: reading of signals in ETCS L1 is an option to generate infill information. |

| Inputs | Outputs |
|---|---|
| - status protection sig<br>- signalling status cut current/ lower pantograph<br>- maximal step speed and slope<br>- traction OFF/ON request<br>- request cut current/lower pantograph<br>- switch position ahead of the vehicle<br>- status direction sig<br>- closed repetition signal acknowledgment<br>- protection signal open<br>- On sight speed until next MA (line side signal)<br>- caution speed on 1000 m | - Movement Authority<br>- TC change of traction system |

Allocated to:

- SCV

### 11.3.127 Manage supervision orders

Description:

| |
|---|
| This function receives direct orders from IM, by means of IPM. |

| Inputs | Outputs |
|---|---|
| - caution speed on a given distance<br>- On sight speed until next MA (line side signal)<br>- cmd_speed_restriction | - On sight speed until next MA (line side signal)<br>- caution speed on 1000 m |

Allocated to:

- SCV

### 11.3.128 Inform IM about prolonged stop

Description:

| |
|---|
| This function informs IM that the train is stopped in rear of a closed signal after a defined delay:<br><br>- delay defined in infra database<br><br>- 5 min by default<br><br>- (optional: marker board value associated to the signal and detected by sensors).<br><br>Rationale: avoid deadlock in case of signaling failure. |

| **Inputs** | **Outputs** |
|---|---|
| - prolonged stop | |

Allocated to:

- SCV

### 11.3.129 Interpret lineside signalling

Description:

| |
|---|
| This function informs Perception that the train will cross a lineside signal or marker board recorded in the infrastructure database and receives the status of this object. |

| **Inputs** | **Outputs** |
|---|---|
| - lineside signal information<br><br>- signal aspect | - signalling status cut current/ lower pantograph<br><br>- status direction sig<br><br>- status spacing sig<br><br>- status protection sig<br><br>- status protection sig<br><br>- status speed sig<br><br>- lineside signal expected<br><br>- status direction sig<br><br>- prolonged stop |

Allocated to:

- SCV

### 11.3.130 Manage traffic

Description:

| |
|---|
| This function operates the trains automatically and interfaces with Operations Manager for specific actions. |

| Inputs | Outputs |
|---|---|
| - route request<br>- possession request<br>- route cancellation request | - route setting |

Allocated to:

- Traffic Management

### 11.3.131 Protect from high voltage switch on

Description:

| |
|---|
| This function transmits the high voltage protection status from Infrastructure Manager to the autonomous train. |

| Inputs | Outputs |
|---|---|
| - high voltage switch on forbidden | - high voltage protection status |

Allocated to:

- Traffic Management

### 11.3.132 Manage stopping points and passing points

Description:

| |
|---|
| This function elaborates the Journey Profile according to:<br><br>- stop requests from RU<br><br>- modifications requested by IPM in case of trackside incident |

| |
|---|
| - modifications requested by ATO if the dwell time can be extended when the passenger flow is not finished and margin is available. |

| Inputs | Outputs |
|---|---|
| - RU defined stop request<br>- request for extended dwell time<br>- Journey Profile Request<br>- new JP requested<br>- Status Report | - mission validation<br>- Journey Profile<br>- coupling authorization<br>- train status |

Allocated to:

- Traffic Management

### 11.3.133 Request train wake-up

Description:

| |
|---|
| This function orders a train awakening. It can be used where there is no mission on-board but it can also supersede a mission if there is one. The function follows this sequence:<br><br>- it checks if ATO is awakened. If not, it orders an awakening of ATO.<br><br>- it orders train awakening depending on the train initial state: high voltage present or not. |

| Inputs | Outputs |
|---|---|
| - cmd train wake-up | - cmd train wake-up |

Allocated to:

- Train Management

### 11.3.134 Determine mission data

Description:

| |
|---|
| This function determines the mission to be sent to a given train to satisfy the customer needs taking into account the technical constraints (change of driver, restrictions on rolling stock...). |

The Train Management send a mission or a modification of mission at any time. If mission is rejected, the Train Management has to stop the train or request to stop it in order to cancel the task in progress and replace it with a new one.

The Train Management is the unique transmission channel of the mission. In case of multiple units, the mission is sent to all ATOs.

A mission related to a train movement allocated within a train path has to be validated by the infrastructure operations manager.

The function defines the sequence of tasks with times of passage and checks that the sequence is consistent regarding location, duration and times of passage. The wake-up time of ATO is defined (ATO remains in sleeping mode when the train is powered off).

The sequence can include an empty task to be completed by the driver (if not completed, the train will be stopped according to the last task and will ask for adding a task i.e. a modification of mission).

Note: even if the concept of empty task is application specific, this need can be generalized to have a manual action in case of degraded situation and avoid a deadlock in operation.

| **Inputs** | **Outputs** |
|---|---|
| - requested mission<br>- brake parameters + modification<br>- brake test type requested<br>- mission validation<br>- local instructions<br>- updated mission<br>- transfer of restrictions<br>- high voltage protection status<br>- train allocation<br>- request task addition<br>- on-going task number<br>- mission modification rejected<br>- task rejected<br>- task delay warning<br>- request powered ATO | - RU defined stop request<br>- request task addition<br>- mission modification<br>- mission |

Allocated to:

- Train Management

### 11.3.135 Register autonomous train unit

Description:

| |
|---|
| This function receives the ATO identity record of each autonomous train, checks it against the train composition foreseen in the mission (consistency with vehicle database), records it and sends related information to the RU.<br><br>The function checks that all train units are registered and controlled by one master ATO.<br><br>Note: ATO version must be checked because a change of version in a fleet can take several weeks. The configuration of the perception is also important in the versioning because some rules could depend on the country (need to detect a firecracker in France for example). |

| Inputs | Outputs |
| --- | --- |
| - ATO identity record<br>- vehicle database | |

Allocated to:

- Train Management

### 11.3.136 Forbid start

Description:

This function informs RU about a TPS intervention in order to inhibit the train departure. During intervention, all headlights (white and red) are switched on. Inhibition is removed at the end of intervention.

| Inputs | Outputs |
| --- | --- |
| - end of intervention<br>- train hold request | - intervention required |

Allocated to:

- Train Management

### 11.3.137 Manage ECM request

Description:

This function transfers the responsibility of the train to ECM when requested and when the train is parked on a maintenance yard (ATO is in sleeping mode).

When ECM has finished his maintenance activities, the system takes back the responsibility of the train with associated restrictions, if any.

| Inputs | Outputs |
| --- | --- |
| - intervention request<br>- train under system responsibility<br>- ATO state | - train under ECM responsibility<br>- train check-out status |

Allocated to:

- Train Management

### 11.3.138 Ensure communication with passengers

Description:

| |
|---|
| This function permits RU to establish communication with onboard passengers:<br><br>- incidents via TIS<br><br>- video link for analyzing situation<br><br>- verbal communication if necessary. |

| Inputs | Outputs |
|---|---|
| - verbal communication<br>- msg_ information_about_incident<br>- cmd_request_interior_video<br>- live_interior_video<br>- verbal communication | - msg_ information_about_incident<br>- live_interior_video<br>- cmd_request_interior_video<br>- verbal communication<br>- verbal communication |

Allocated to:

- Train Management

### 11.3.139 Manage Remote Driver request

Description:

| |
|---|
| This function transfers the responsibility of the train to Remote Driver when requested. When Remote Control is finished, the system takes back the responsibility of the train.<br><br>Three remote controls are possible:<br><br>- Local remote control under the supervision of local staff (system remains active, ATO-AV is in Not Available mode). Driving commands are given through C48 or optionally via C7 (local command for 1 or 2 wheel rotations with ATO-AV in local control mode).<br><br>- Local remote control via the function «communicate with TPS». |

| |
|---|
| - Remote control in case of system failure (rescue tool acting directly on TCMS). |

| Inputs | Outputs |
|---|---|
| - train under system responsibility<br>- remote control request<br>- ATO state<br>- TCMS in RC mode | - train under remote driver responsibility<br>- train check-out status<br>- remote control mode ON/OFF |

Allocated to:

- Train Management

### 11.3.140 Manage TPS request

Description:

| |
|---|
| This function transfers the responsibility of the train to TPS when requested and when the train is parked on a shunting yard (ATO is in sleeping mode). When TPS has finished his preparation activities, the system takes back the responsibility of the train with associated restrictions, if any.<br><br>Once Train Preparation Staff has the control, the function manages his orders:<br>- wake-up request (ATO is in sleeping mode and must enter in Standby mode before train preparation)<br><br>- coupling request<br><br>- uncoupling request (request compression)<br><br>- test brakes.<br><br>Note: The coupling/uncoupling operations can be assisted by GoA34 system in an elaborated solution (specific operational mode with specific sensors to detect the compression, see «Measure distance between loco and wagons») or limited to a remote driving in the simplest solution depending on the freight wagon. The local remote control should be limited to small distances (a few meters). |

| Inputs | Outputs |
|---|---|
| - coupling ok<br>- request coupling<br>- request compression<br>- uncoupling OK<br>- request train wake-up<br>- electro-pneumatic brake test ok<br>- brake release ok<br>- apply brake request<br>- release brake request<br>- train under system responsibility<br>- ATO state<br>- intervention request | - request compression<br>- request train wake-up<br>- uncoupling OK<br>- train under TPS responsibility<br>- train check-out status<br>- apply brake request<br>- release brake request<br>- brake release OK<br>- electro-pneumatic brake test OK<br>- coupling OK<br>- request coupling |

Allocated to:

- Train Management

### 11.3.141 Monitor trains

Description:

This function monitors trains and requests specific TCMS actions when requested.

Day to day operation is managed by Train Management and operational restrictions are transmitted to IM via C35 (IM is also informed via trackside IPM).

Note: A train register dedicated to operational restrictions could be a component of Train Management but it is a matter of national implementation, there is no need for an interoperable logical component. Driver receives today such information via TCMS display. Such train register could be an extension of the vehicle registers managed by RU:

- ERATV is a fixed Vehicle register at European level for TSI OPE (interoperability between rolling stock and infrastructure). Example: a TGV consist.
- NVR is a fixed Vehicle register giving a unique ID for each vehicle. Example: a TGV consist of 2 locos and 8 coaches is defined by 10 IDs.

| Inputs | Outputs |
| --- | --- |
| - train check-out status | - ATO state |
| - passenger alarm reset | - alarm signal |
| - lock_coach | - lock_coach |
| - delay_door_closing | - passenger alarm reset |
| - Status Report | - ATO state |
| - status of safety related equipment | - ATO state |
| - train check-out status | - local_alarm_raised |
| - train check-out status | |
| - maintenance data | |
| - alarm signal | |

Allocated to:

- Train Management

### 11.3.142 Process remote driving commands

Description:

| |
| --- |
| This function activates the cab for remote driving and processes the remote driver commands. In case of loss of communication, the function will apply emergency brakes. |

| Inputs | Outputs |
| --- | --- |
| - move forward/backward | - move forward/backward |
| - TCMS in RC mode | - cmd_brakes |
| - cmd_brakes | - ETCS isolation request |
| - isolation request | - door opening request |
| - door opening request | |

Allocated to:

- Train Management

### 11.3.143 Provide video stream

Description:

| |
|---|
| This function transmits a video stream of the train environment on RU request. Video stream is coming directly from TCMS through C48 interface to permit a remote driving in case of system failure including a possible failure of PER module. |

| Inputs | Outputs |
|---|---|
| - video stream request<br>- video stream request<br>- video stream | - video stream<br>- video stream<br>- video stream request |

Allocated to:

- Train Management

### 11.3.144 Transmit adhesion factor

Description:

| |
|---|
| This function transmits adhesion factor (slippery or non-slippery rail) to onboard ETCS. |

| Inputs | Outputs |
|---|---|
| - slippery zone | - adhesion factor |

Allocated to:

- Train Control

### 11.3.145 Transmit Emergency Stop

Description:

| |
|---|
| This function transmits Emergency Stop message to onboard ETCS. Emergency pantograph drop can also be requested.<br><br>Note: New feature to be allocated to Train Control (+ sending to Train Protection). |

| Inputs | Outputs |
|---|---|
| - cmd_ETCS_stop | - ES message |

Allocated to:

- Train Control

### 11.3.146 Transmit immobilization order

Description:

| |
|---|
| This function permits to immobilize onboard ETCS with the following order:<br><br>- ETCS Written Order 03: Obligation to remain at a standstill.<br><br>Note: New ETCS function to be allocated to Train Control (+ sending to Train Protection). |

| **Inputs** | **Outputs** |
|---|---|
| - cmd_ETCS_order03 | |

Allocated to:

- Train Control

### 11.3.147 Transmit MA

Description:

| |
|---|
| This function transmits Movement Authority to onboard ETCS. |

| **Inputs** | **Outputs** |
|---|---|
| - signalling states | - MA<br>- MA |

Allocated to:

- Train Control

### 11.3.148 Transmit override order

Description:

| |
|---|
| This function permits onboard ETCS to pass an EOA with the following order:<br><br>- ETCS Written Order 01: Permission to pass an EOA. |

Note: New ETCS function to be allocated to Train Control (+ sending to Train Protection). Alternative solution is to use IPM channel.

| Inputs | Outputs |
|---|---|
| - cmd_ETCS_order01 | |

Allocated to:

- Train Control

### 11.3.149 Transmit restrictions order

Description:

This function permits onboard ETCS to run with restrictions with the following order:

- ETCS Written Order 05: Obligation to run under restrictions.

Note: New ETCS function to be allocated to Train Control (+ sending to Train Protection).

| Inputs | Outputs |
|---|---|
| - cmd_ETCS_order_05 | |

Allocated to:

- Train Control

### 11.3.150 Transmit start order

Description:

This function permits onboard ETCS to restart after a train immobilization with the following orders:

- ETCS Written Order 02: Permission to proceed after a trip

- ETCS Written Order 04: Revocation of ETCS Written Order 03 (Obligation to remain at a standstill).

Note: New ETCS function to be allocated to Train Control (+ sending to Train Protection).

| Inputs | Outputs |
|---|---|
| - cmd_ETCS_start | - cmd_ETCS_start |

Allocated to:

- Train Control

### 11.3.151 Transmit TSR

Description:

| |
|---|
| This function transmits Temporary Speed Restriction (TSR) to onboard ETCS. |

| Inputs | Outputs |
|---|---|
| - cmd_temporary_speed_restriction | - TSR |

Allocated to:

- Train Control

### 11.3.152 Track train units

Description:

| |
|---|
| This function receives the ETCS position reports of the train units. |

| Inputs | Outputs |
|---|---|
| - position report | |

Allocated to:

- Train Control

### 11.3.153 Command and supervise horn

Description:

| |
|---|
| This function commands the horn at specific infrastructure locations, tunnel entry/exit or when persons are detected on or near the track. It implies to detect the horn sound and to report possible anomalies because horn activation is safety related. |

Note: allocated to Train Protection because ETCS manages already the track conditions (an alternative is IPM-OB).

| Inputs | Outputs |
|---|---|
| - horn status<br>- horn request<br>- horn activation locations<br>- level crossing to run with caution speed<br>- location + trainset heading | - horn request |

Allocated to:

- Train Protection

### 11.3.154 Command Emergency Brake

Description:

This function is train dependent and requests emergency brake application when decided by Train Protection or IPM-OB.

This function resets the EB command in case IPM-OB informs that obstacle has disappeared. The release of EB command has to be configurable, it should be possible with electric brakes but not with magnetic brakes that will be applied by TCMS until stop for safety reasons (a release would break the train because of the different reaction times in the train units).

| Inputs | Outputs |
|---|---|
| - emergency stop<br>- cmd_emergency_brake | - cmd EB<br>- cmd_release_EB_order |

Allocated to:

- Train Protection

### 11.3.155 Command pantograph and main switch

Description:

This function detects that the train is on a track location where it is necessary to cut the current or lower the pantograph according to the track conditions and generates the corresponding

| |
|---|
| orders.<br><br>This function reacts also to incidents detected by IPM for trains having a pantograph without Automatic Drop Device. It sends an emergency drop command to TCMS when required.<br><br>Note: allocated to Train Protection because ETCS manages already the track conditions (an alternative is IPM-OB). |

| Inputs | Outputs |
|---|---|
| - cmd emergency pantograph drop<br>- pantograph drop request<br>- pantograph position | - cmd_pantograph_drop<br>- cmd main circuit breaker closure<br>- cmd main circuit breaker opening<br>- cmd lower pantograph<br>- cmd raise pantograph |

Allocated to:

- Train Protection

### 11.3.156 Compute static and dynamic data for ATO

Description:

| |
|---|
| This function computes ETCS_ATO_Static (packet 5) and ETCS_ATO_Dynamic (packet 6) for ATO. |

| Inputs | Outputs |
|---|---|
| - MA<br>- cmd_ETCS_start | - MA<br>- BG list<br>- ETCS_ATO_Dynamic<br>- NID_OPERATIONAL<br>- NID_ENGINE |

Allocated to:

- Train Protection

### 11.3.157 Compute train unit position

Description:

| |
|---|
| This function computes and reports the safe train unit position to Train Control. |

| Inputs | Outputs |
|---|---|
| - msg_loss_of_integrity<br>- location + trainset heading<br>- train configuration | - position report |

Allocated to:

- Train Protection

### 11.3.158 Determine ETCS mode

Description:

| |
|---|
| This function manages the transitions between ETCS modes (see STM ETCS). |

| Inputs | Outputs |
|---|---|
| - Q_AD_MODE_REQUEST | - STM status |

Allocated to:

- Train Protection

### 11.3.159 Manage exchanges with driver

Description:

| |
|---|
| This function acquires the inputs from the driver and displays information relevant for him. |

| Inputs | Outputs |
| --- | --- |
| - ATO engage button<br>- override button<br>- ATO disengage button<br>- TBL control | - ATO engage button<br>- ATO disengage button<br>- TBL control |

<u>Allocated to:</u>

- Train Protection

### 11.3.160 Monitor speed and distance

<u>Description:</u>

This function monitors the speed of the train versus its position, in order to assure that the train remains within the given speed and distance limits.

Note (subset-026): The speed and distance monitoring of the on-board can only assure this when the following necessary conditions are fulfilled:

- Brake system of the train functions as specified

- Wheel/rail adhesion is sufficient for the required safe deceleration

- Brake characteristics (and other Train related inputs) are correctly entered into the on-board.

| Inputs | Outputs |
| --- | --- |
| - adhesion factor<br>- Movement Authority<br>- remote control speed<br>- TSR<br>- MA<br>- location + trainset heading<br>- TC change of traction system<br>- obstacle MA<br>- maximum train speed | - EOA reached<br>- next danger point |

Allocated to:

- Train Protection

### 11.3.161 Monitor train integrity

Description:

| |
|---|
| This function checks the train integrity (Train Integrity Monitoring System). |

| Inputs | Outputs |
|---|---|
| | - msg_loss_of_integrity<br>- msg_loss_of_integrity |

Allocated to:

- Train Protection

### 11.3.162 Store Train Protection parameters

Description:

| |
|---|
| This function records ATP parameters. |

| Inputs | Outputs |
|---|---|
| - ATP parameters validated<br>- ATP parameters | |

Allocated to:

- Train Protection

### 11.3.163 Supervise emergency brake chain test

Description:

| |
|---|
| This function tests the emergency brake chain. |

| Inputs | Outputs |
| --- | --- |
| - EB test status | - EB test time and status<br>- cmd test EB |

Allocated to:

- Train Protection

#### 11.3.164 Supervise runaway movement

Description:

| |
| --- |
| This function supervises standstill, roll away and reverse movement. |

| Inputs | Outputs |
| --- | --- |
| - travelling direction 1 or 2<br>- current speed<br>- measured traction force<br>- location + trainset heading | - cmd Service Brake |

Allocated to:

- Train Protection

#### 11.3.165 Train trip

Description:

| |
| --- |
| This function leads onboard ETCS to Trip mode with the application of emergency brakes. |

| Inputs | Outputs |
| --- | --- |
| - ES message<br>- EOA reached | - cmd_emergency_brake<br>- cmd_pantograph_drop |

Allocated to:

- Train Protection

# 12 Use cases

## 12.1 Introduction

12.1.1.1.1 The Use Cases are based on the operational contexts OC1, OC2, OC3, OC4 and OC5 identified in chapter 8.2. They focus on the user needs related to full automatic train operation (OC1) and to the transitions between OC1 and the other operational contexts in chapter 12.14.

12.1.1.1.2 The Use Cases are expressed under the form of sequence diagrams showing the various interactions between the actors and the main logical components, each one being represented by a timeline. Each timeline describes the functions and exchanges involved in these interactions. The timeline includes also the mode associated to the logical component or the state associated to the actor when the scenario leads to a change of mode or state (door opened or closed for example).

12.1.1.1.3 According to the limitations defined in 6.1, only the timelines associated to ATO-AV, ATO-AT, IPM-OB and PER components are under the scope of this specification.

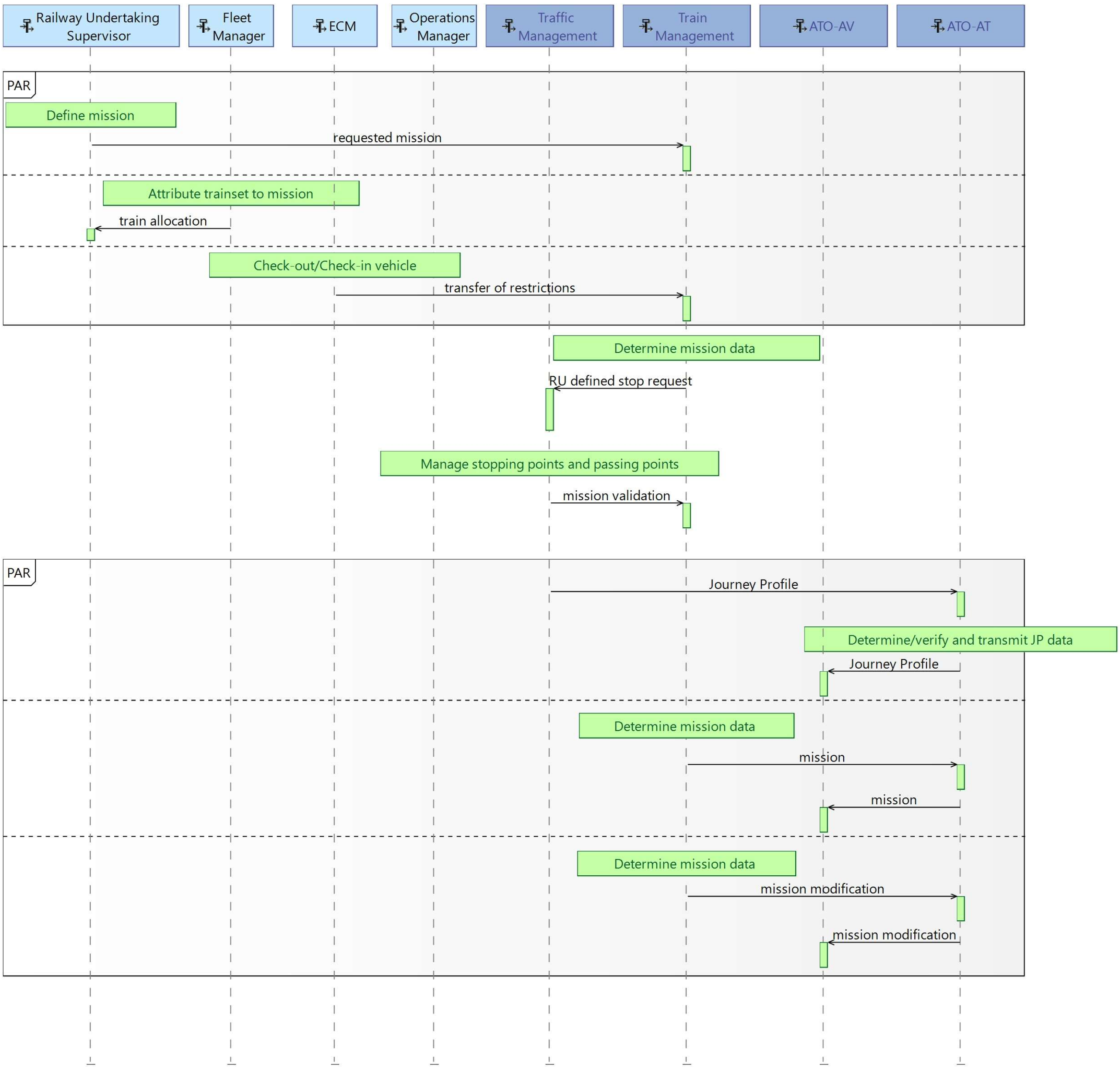
12.1.1.1.4 The sequence diagrams use specific symbols and constructions for modelling. Actors are represented with light blue boxes, logical components with dark blue boxes, functions with green boxes, modes with grey bubbles, data flows with arrows and comments with yellow boxes. Constructions permit to introduce conditions (ALT), iterations (LOOP), parallelism (PAR), options (OPT) and references to other UCs (REF).

12.1.1.1.5 The sequence diagrams are informative only. They permit to make the link with the functions of chapter 11 but they do not reflect all possible combinations existing in a test scenario where specific values of variables are set. A textual description is added where necessary to detail the behavior expected from the logical components to answer to the Use Case.

## 12.2 Operations related to mission

### 12.2.1 Elaborate mission and journey profiles

This Use Case focuses on the preparation of the train mission with the definition of stopping points, passing points and possible restrictions.




### 12.2.2 Entry in technical centre

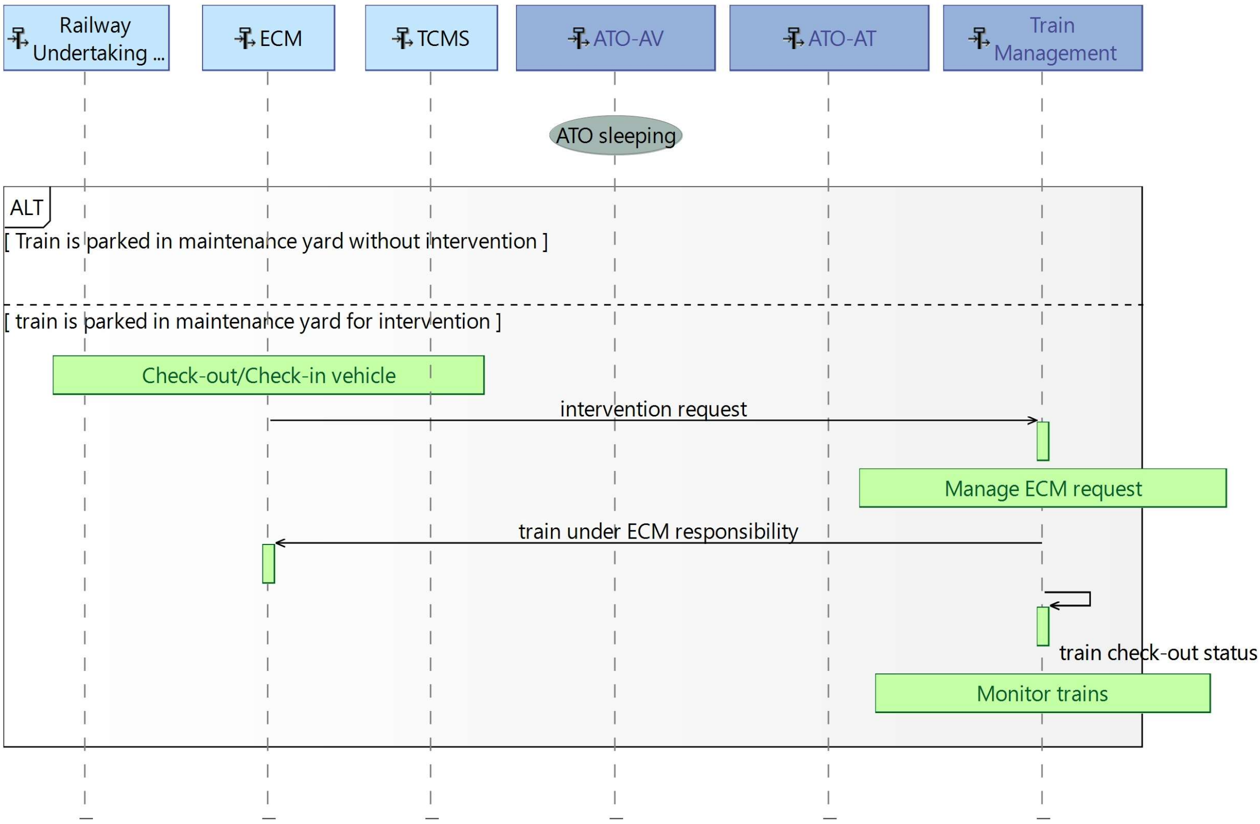
This Use Case describes the entry of a train on a maintenance yard for maintenance activities.

<u>Description</u>

Once the train is on a maintenance yard, a handover with the technical centre is necessary for the transfer of responsibility in case of intervention. Whatever happens inside is of no interest for the standardization but a standard check-in/check-out mechanism is necessary to inform RU that the train is no more available until maintenance is finished.

Local train movements are managed by ECM and a local TMS.

Note: it is possible to go to the depot in automatic driving in metro applications.



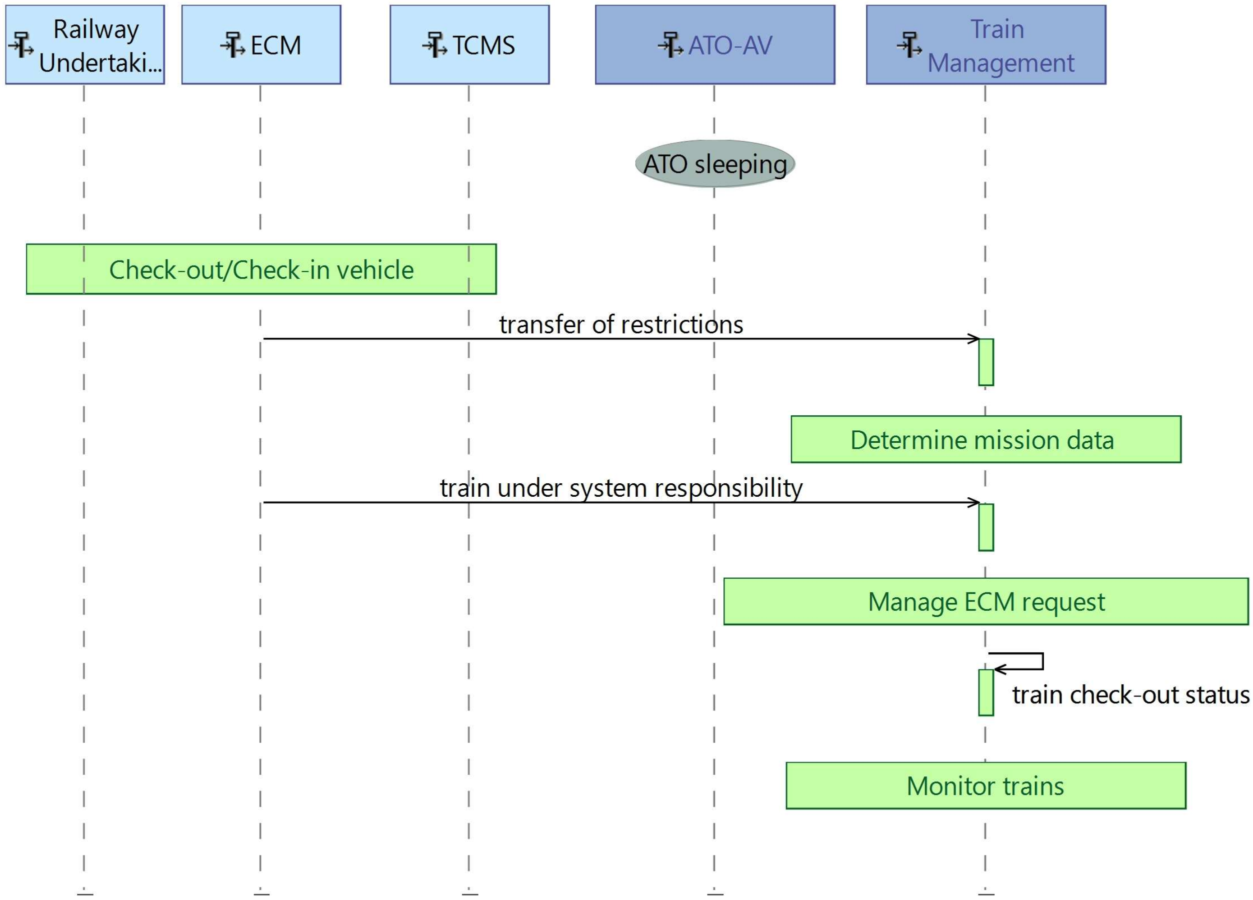

### 12.2.3 Exit from technical centre

This Use Case describes the activities to perform on a maintenance yard when maintenance activities are finished.

<u>Description</u>

Once maintenance is finished in the technical centre, ECM will manage the local train movements with local TMS to reach the handover area with TMS. A standard check-in/check-out mechanism is necessary to inform TMS that the train is ready for operation and to transfer the responsibility of the train from ECM to RU.

Train is on a maintenance yard and ATO is in sleeping mode, waiting for a mission.



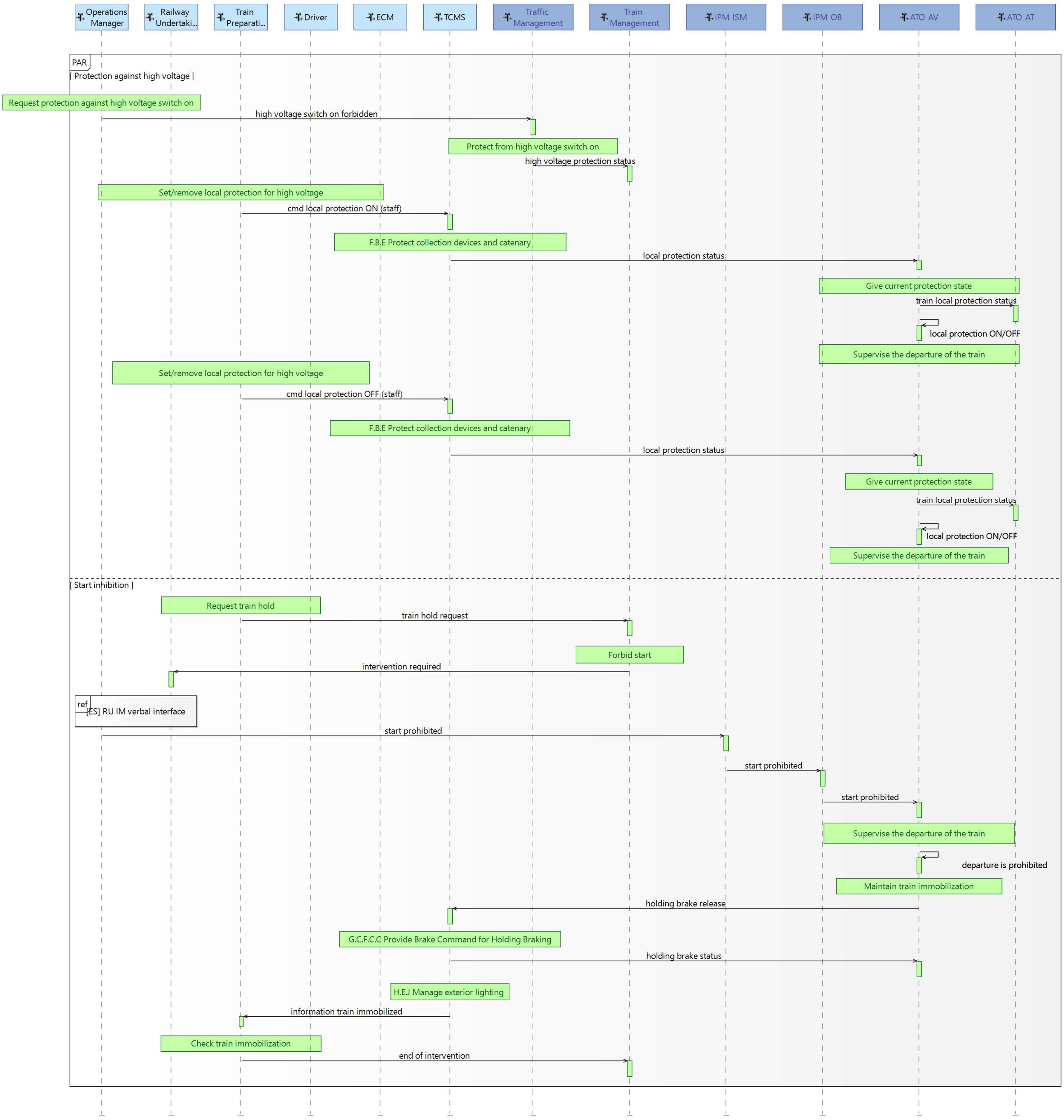

### 12.2.4 Perform train maintenance or cleaning

This Use Case describes immobilization and protection activities required for maintenance or cleaning of an autonomous train.

Description

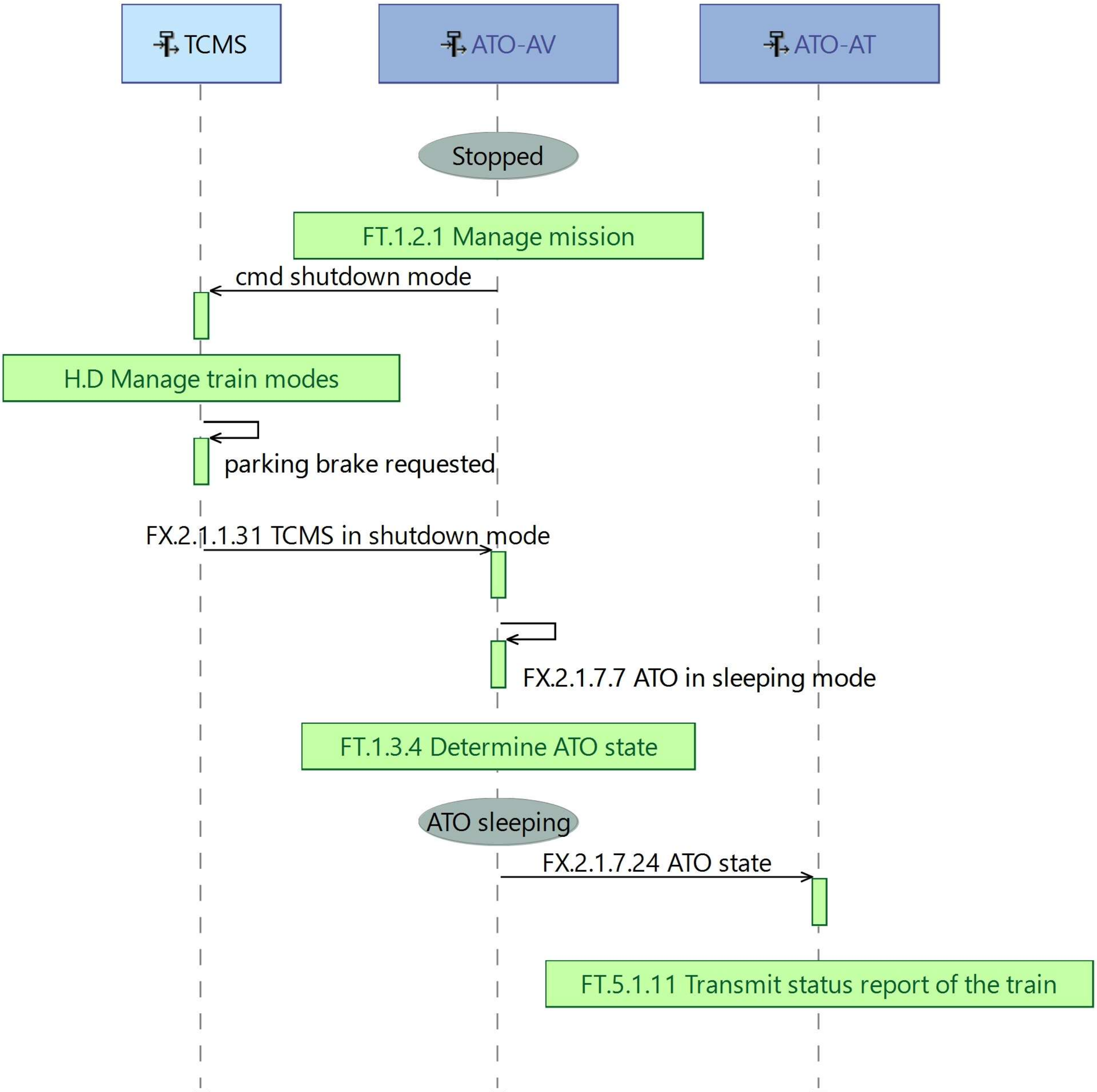
Train maintenance or exterior cleaning can be performed outside a technical centre (manual cleaning or repair of a door for example). For TMS, it means that the train is no more available until maintenance is finished. A standard check-in/check-out mechanism is necessary to inform TMS and intervention staff must be protected during this time.

The protections are specific, they depend on application. The Use Case describes a protection against high voltage (catenary voltage control combined with a local protection installed on the train) and the inhibition of the train departure until work is finished.




## 12.2.5 Park autonomous train

This Use Case describes the deactivation of a train when mission is finished.

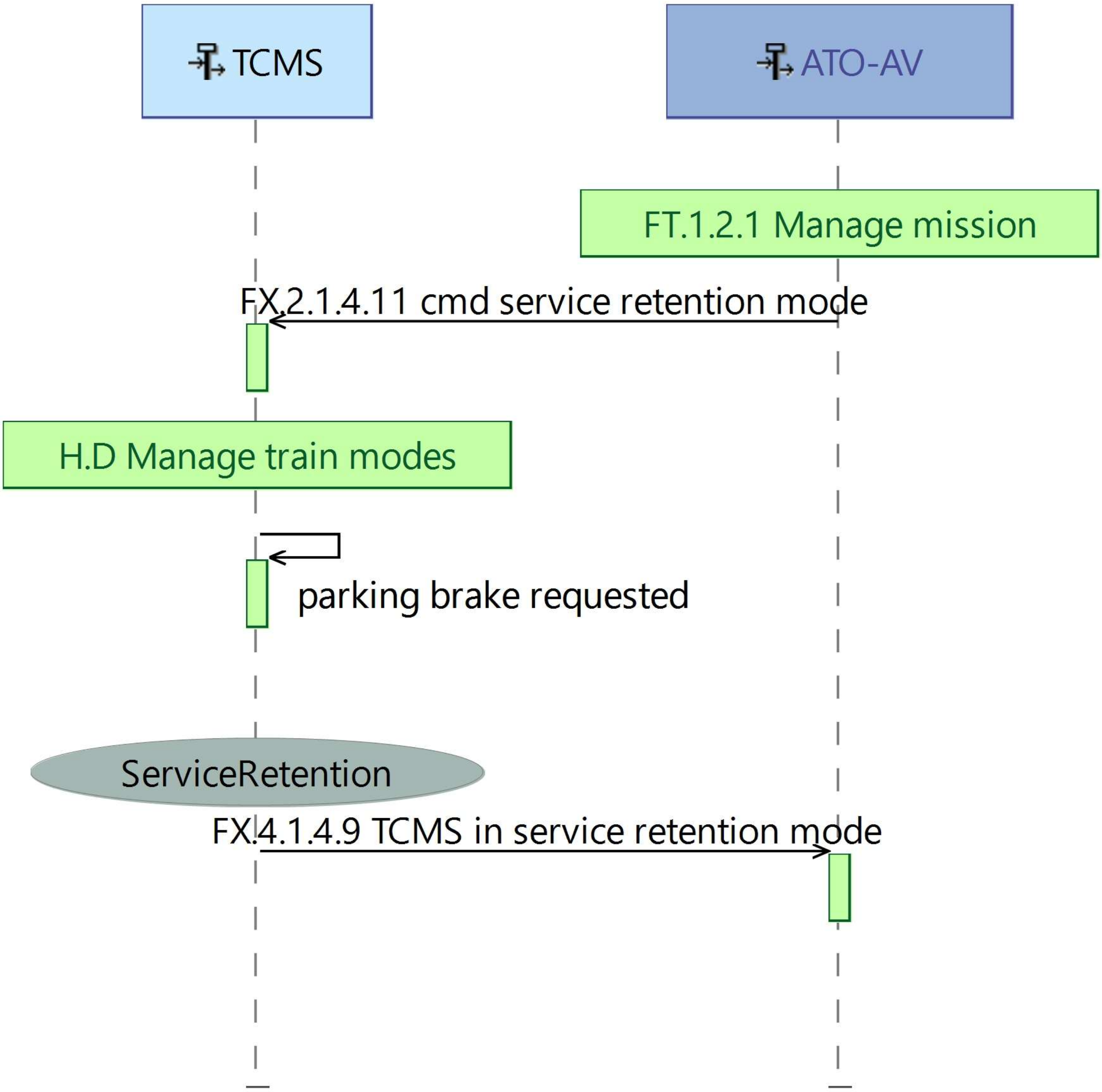



### 12.2.6 Switch to retention of service

This Use Case describes the entry of TCMS in retention of service mode.

Description

The purpose of this UC is saving energy. Without driver, the entry of TCMS in service retention mode is configured by mission.




## 12.3 Autonomous train preparation

### 12.3.1 Awakening sequence of ATO-AV

This Use Case describes the first steps of awakening of an autonomous train with the wake-up of ATO-AV.

Description

The Use Case is to have a green train (train not powered when not operated). A standard interface is required to wake-up the train without driver. Solution is a wake-up box, part of ATO-

AV (current assumption) or TCMS (to be discussed with Connecta or remote driving in Tauro project).

With TCMS in initial state shutdown, current assumption is a sleeping state for the ATO-AV component. Awakening of ATO-AV can be performed automatically at recorded time or on request to receive mission and/or journey profile information.

At power-up, only one ATO-AV must be the master. The Train Management wakes-up the ATO-AV that has to lead the train for the planned mission (all its functions will be activated while slave ATO-AV(s) will have a reduced set of functions to manage the sensors and the communication sessions). For example, a train unit composed of 3 consists ATO-AV 1/2/3 will continue with ATO-AV 1 master with a JP in the same travelling direction than previous mission but ATO-AV 3 will become the master with a JP in the reverse direction.

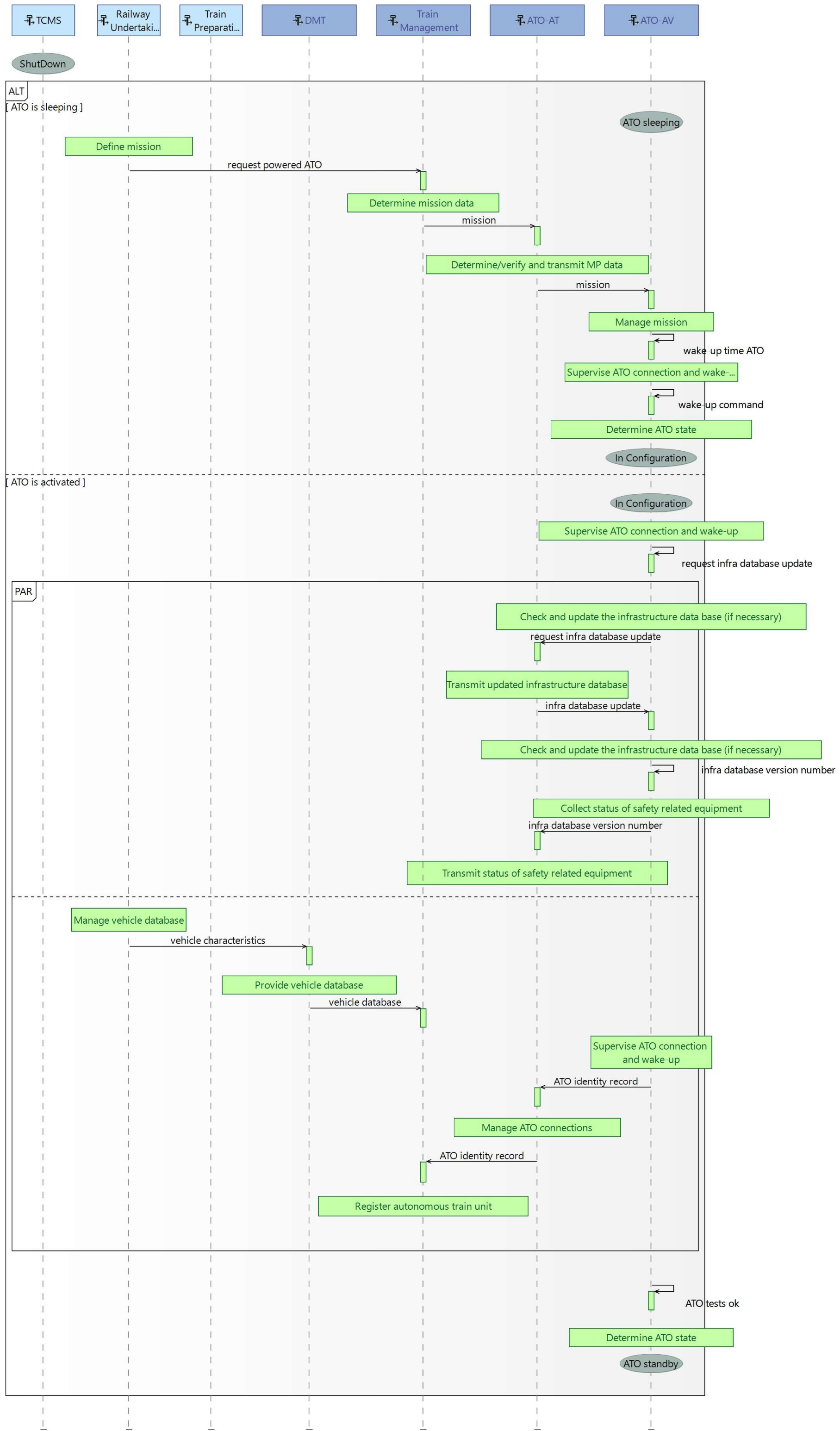
After power-up, the mission will be managed by the leading ATO-AV but all ATO-AVs of the train unit should also receive the MP because each ATO-AV could become a leading ATO-AV after a splitting operation.

The inauguration starts with the determination of the direction (see SN.6.4.5 - Determine and select travelling direction). The information about the Vehicle(s)/Consist(s) to be used is given by the MP and the other information by the JP/SP.

Master ATO-AV commands TCMS to power up the train (more precisely: to execute the necessary steps to bring the train to a defined mode). It leads to power-on ETCS that will use the positive signal from Cold Movement Detector to validate the train position.

After the direction determination, it has to be checked if the Cab/Master ATO-AV is ready for operation and if the ATO identity Card is compliant with the intended Mission. In case of error, alternative procedures have to be applied and agreed between IM and RU. For example, the mission could be interrupted or modified if it is still possible to run with the Master ATO-AV for the first part of the journey.

The inauguration ends by reporting its result to Train Management through ATO-AT.




## 12.3.2 Awakening sequence of autonomous train

This Use Case describes the awakening sequence of a train after ATO-AV wake-up.

Description

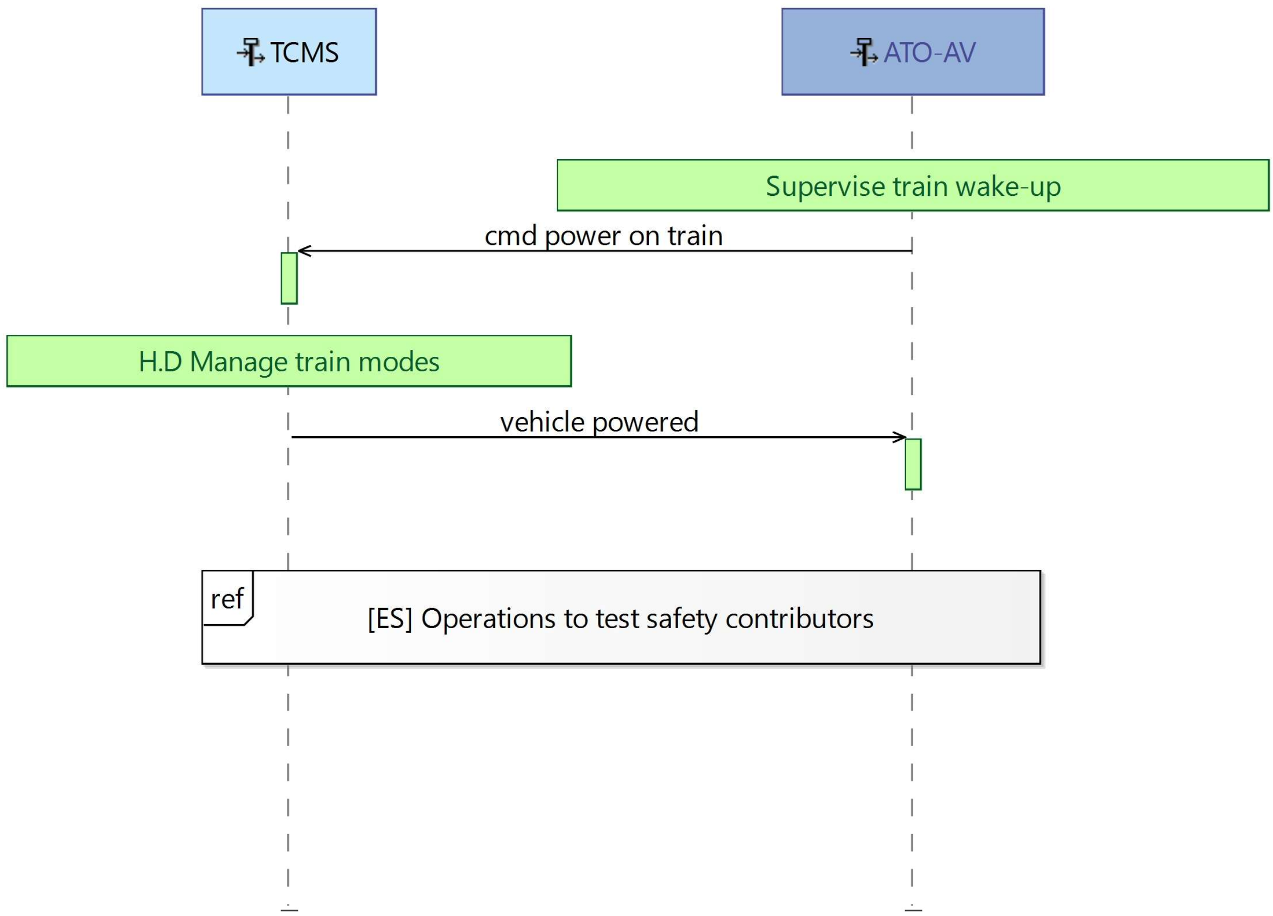
Current assumption is a train powered off with TCMS in shutdown mode and awaken by ATO-AV with a power on command.

Electric trains require to raise the pantograph with pneumatic pressure assisted by batteries. Modern trains raise the pantograph before a battery problem occurs while for other trains, it is assumed that battery is ok before parking in order to be able to raise of the pantograph at wake-up (exported constraint to train, no charging cable is expected or if yes, it is outside GoA34 operation).

Self-propelling trains require a signal to start.

Before embarkment of passengers, the train must be heated or cooled down.

A TCMS mode is necessary after train inauguration to inform ATO-AV that the train is ready for GoA34 operation (to be discussed with Connecta).



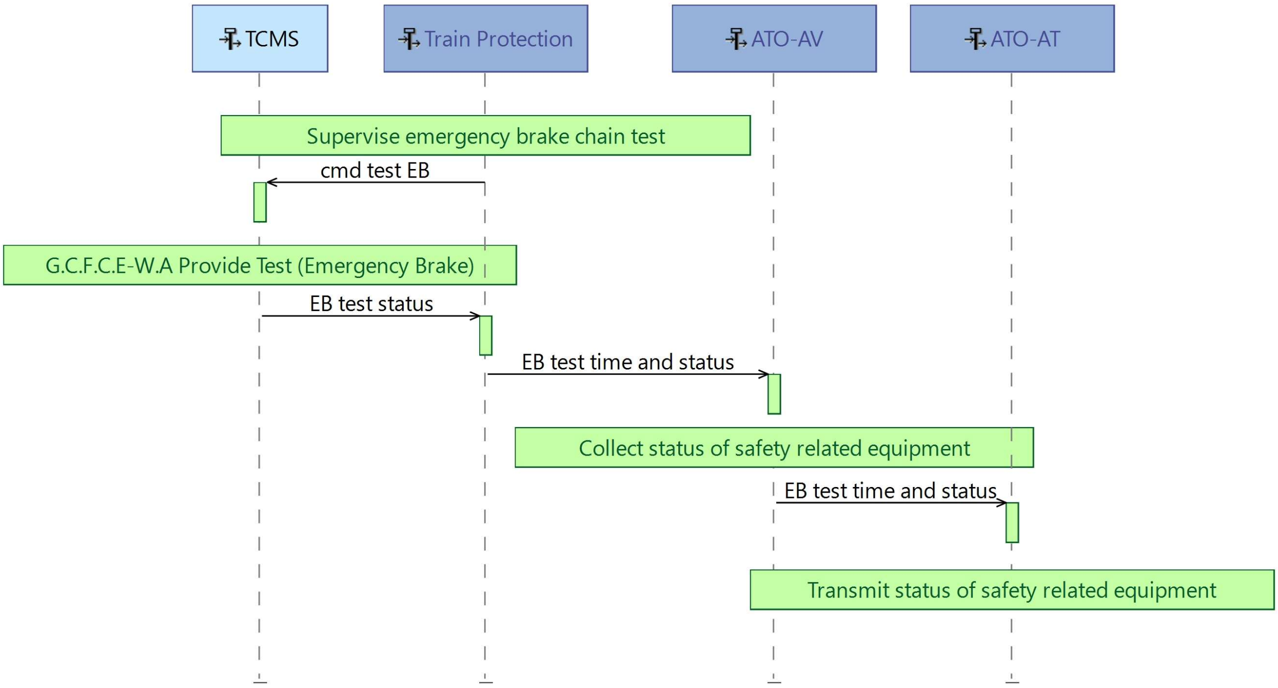
### 12.3.3 Operations to test safety contributors

This Use Case describes the tests to be performed on elements associated to the safety.

Description

Failures with an operational impact can lead to modify a mission (STM failure for example), reporting must be standardised. An example of emergency brake test is shown in the figure.

Detailed diagnosis can be Rolling Stock supplier specific when related to maintenance.



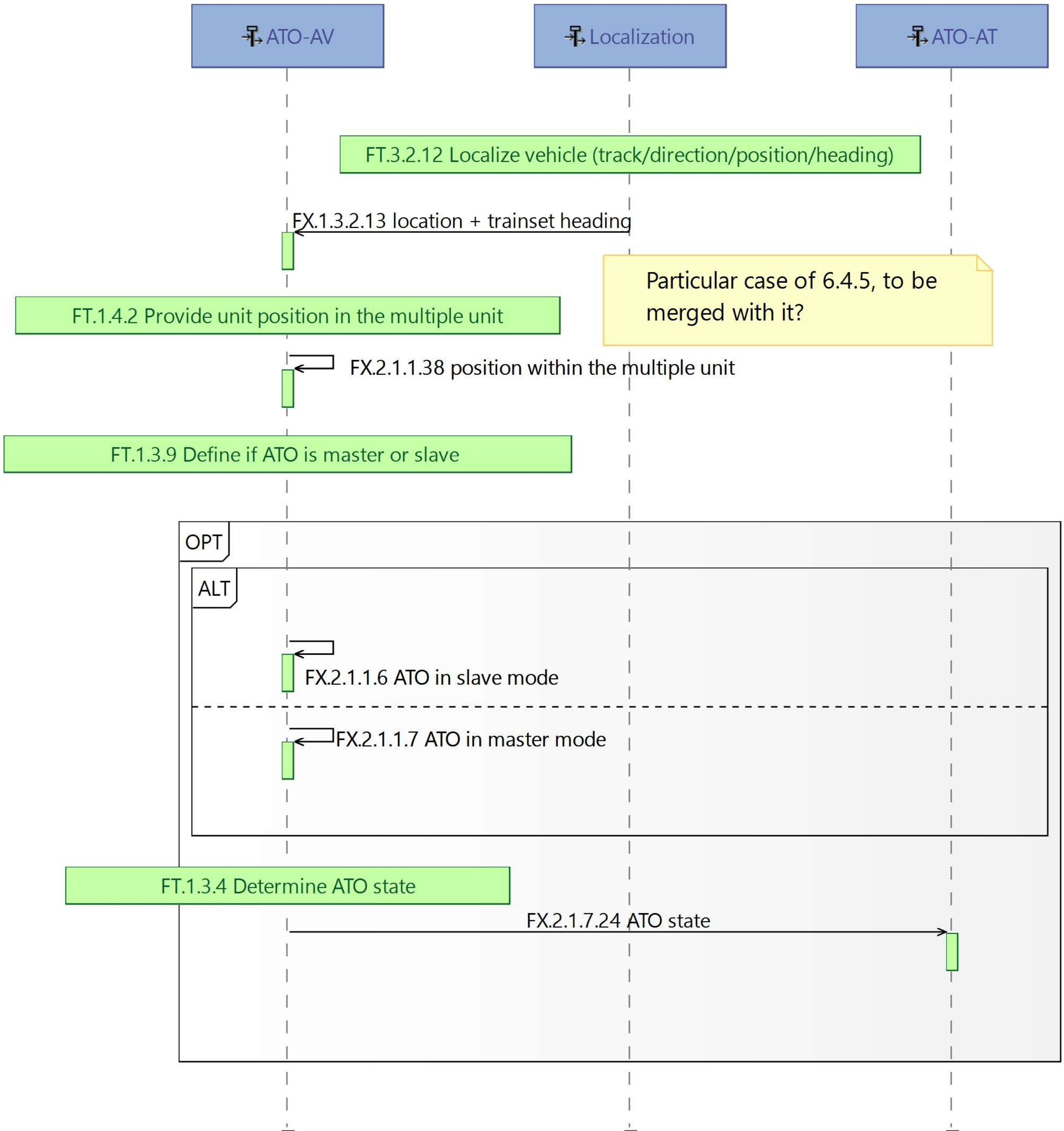

### 12.3.4 Initialization sequence for a multiple unit movement

This Use Case defines the master ATO and the slave ATO(s) during the initialization sequence of a multiple unit.

Description

A train unit composed of several train consists must follow the process described for one consist (Determine and select travelling direction). It is assumed that Train Protection, ATO-AV and TCMS are on the same consist (there is no distribution of lead systems over different consists).

This process is currently not applicable to banking locomotives because the digital automatic coupler is not yet available. Today, the driver of a banking loco pushes the leading loco until the top of a hill before to reverse and there is no physical coupling. Voice communication with the leading loco is not always required. It is assumed that banking operation is limited to a few lines where the existing procedure could be kept until digital automatic coupler is ready before to upgrade such line with GoA34. Regarding ETCS, the banking locomotive was excluded from TSI 2022 (no physical coupling).




### 12.3.5 Train Protection configuration

This Use Case is related to the automatic configuration of Train Protection without driver.

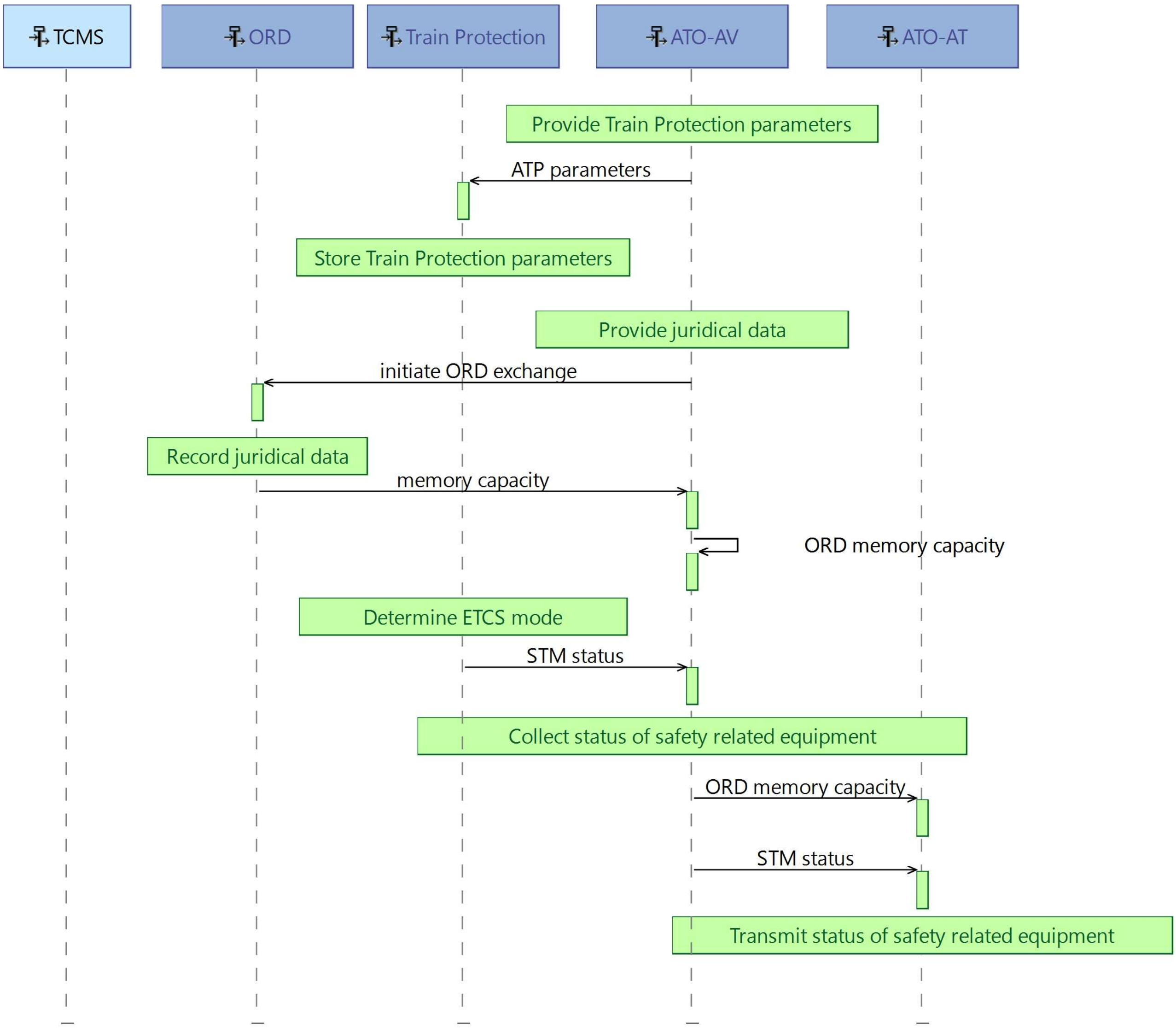
Description

The current allocation of «Provide Train Protection parameters» description will probably change because these parameters are safety related.

With a fixed consist, it could be done automatically by TCMS and Train Protection (to be confirmed by safety analysis). With a digital freight train, the existing data entry procedure in ETCS could be simplified.

A standard is necessary to send these data to ETCS. A procedure with Train Control and IPM trackside could be a solution (outside the scope of GoA34). Different SIL0 channels could also be considered or a direct link between RU and TCMS.

Note: Maximum train speed is provided by TCMS and all data are not safety related.



### 12.3.6 Determine and select travelling direction

This Use Case describes how to activate the right cab with ATO in GoA4.

Description

The selection of the right cab is a task normally performed by the driver. The front of the train is given by the cab selected by the driver. Then, a forward movement leads the train in this direction and a backward movement leads the train in the opposite direction.

Even without driver, an active cab must be defined in order to keep the same conventions than other GoA levels. See subset-026, 3.6.1.5: If there is an active cab, this one defines the orientation of the train, i.e. the side of the active cab shall be considered as the front of the train. If no cab is active, the train orientation shall be as when a cab was last active. The following assumptions are done for the active cab:

- The active cab is the cab at the front end of the train unit («cab anywhere» concept is not mature enough).

- Train Protection, ATO-AV and TCMS are on the same consist (there is no distribution of lead systems over different consists).

- The train unit is equipped with Cold Movement Detection.

In GoA4, two pre-conditions are necessary to perform a change of cab automatically:

- the train unit is stabled at the indicated last position

- the requirements to reuse the last position upon power up are fulfilled (ETCS mode different from No Power or Cold Movement Detection is running and signals «no cold movement»).

ATO-AV determines from the Journey Profile the scheduled direction of movement and based on that the cab / front end to be activated:

- ATO-AV remembers the last Q_SPDIR upon which the train arrived.
- ATO-AV remembers the train configuration upon arrival including which cab / front end was active.
- ATO-AV compares the Q_SPDIR in the JP for departure with the JP from arrival. If it is equal, it activates the cab that was active upon arrival. If not, it activates the opposite cab.
- ATO-AV commands TCMS to activate the cab that was determined to lead the train.

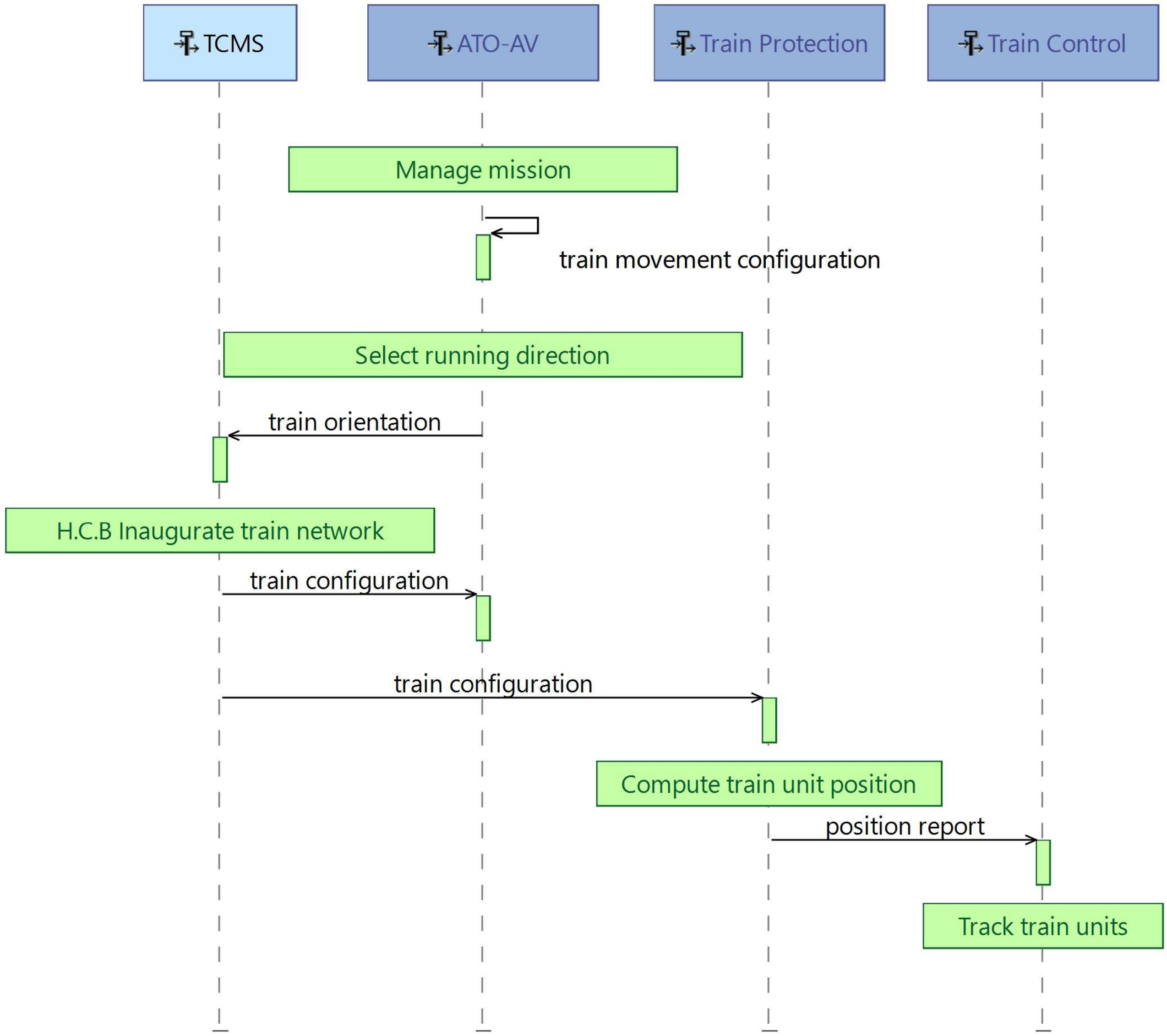
- TCMS carries out the activation of the cab, it implies a re-inauguration of the train unit within 15s (assumption to be confirmed).

At this stage, the cab compatible with the movement direction from the JP is activated in SIL0 but the verification of the direction of movement is not yet done:

- ETCS-OBU must receive the information about the activated cab and detect a change of active cab since the last position report.
- ETCS-OBU must compute a new position for the new front end and report it to Train Control. Example: (LRBG = b1, D_LRBG = 600 m, Q_DIRLRBG = reverse, Q_DIRTRAIN = reverse) converted into (LRBG = b1, D_LRBG = 600m-train length, Q_DIRLRBG = nominal, Q_DIRTRAIN = nominal (after first movement at the latest).
- Train Control must issue a MA when the set route is compatible with the train unit front end reported in the new position.

The post-conditions are:
- If the set route is compatible with the activated cab / determined train unit front end, the train unit has received an MA and can move in the planned direction.
- If not, the train has not received an MA.

For the first movement or in case of degraded mode, the position report is unknown and the solution is not yet defined. The intervention of a local or remote driver could be necessary to start in SR mode until transition to FS mode (in place of a nominal movement in FS mode from depot to mainline).

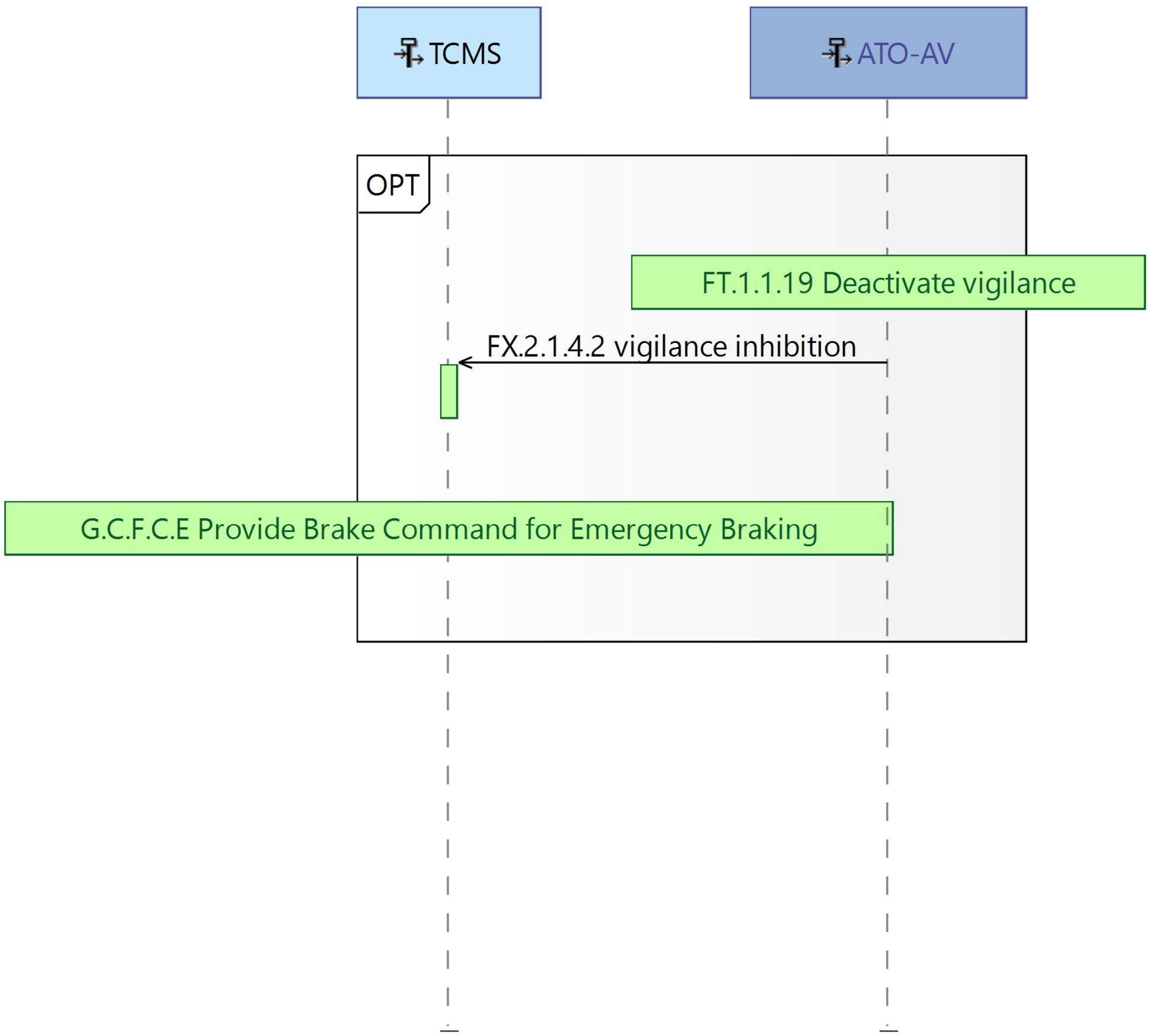



### 12.3.7 Deactivate vigilance

This Use Case details the actions related to vigilance system.

<u>Description</u>

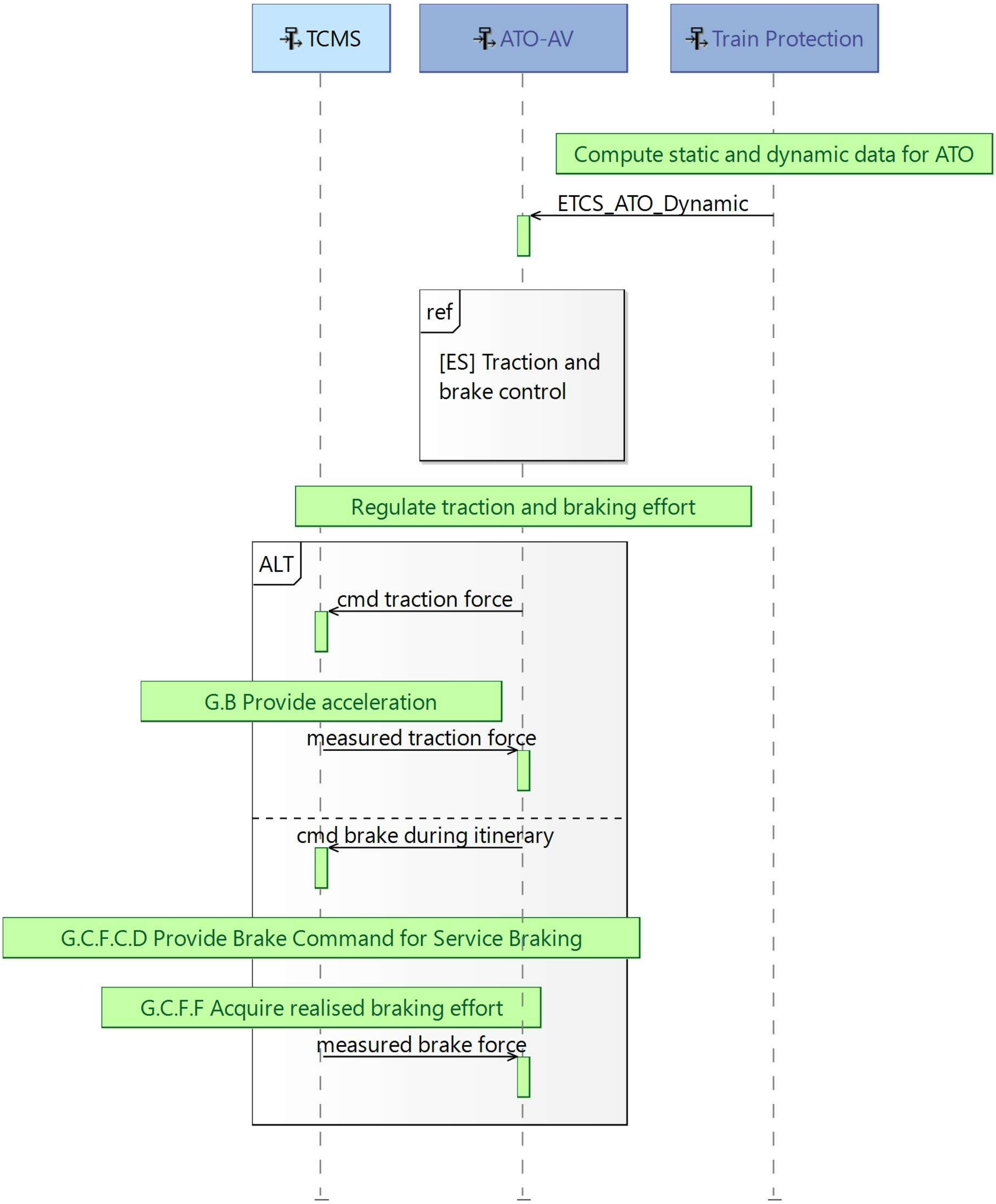
The current allocation of «Deactivate vigilance» function will probably change because this function is safety related.




## 12.4 Move autonomous train

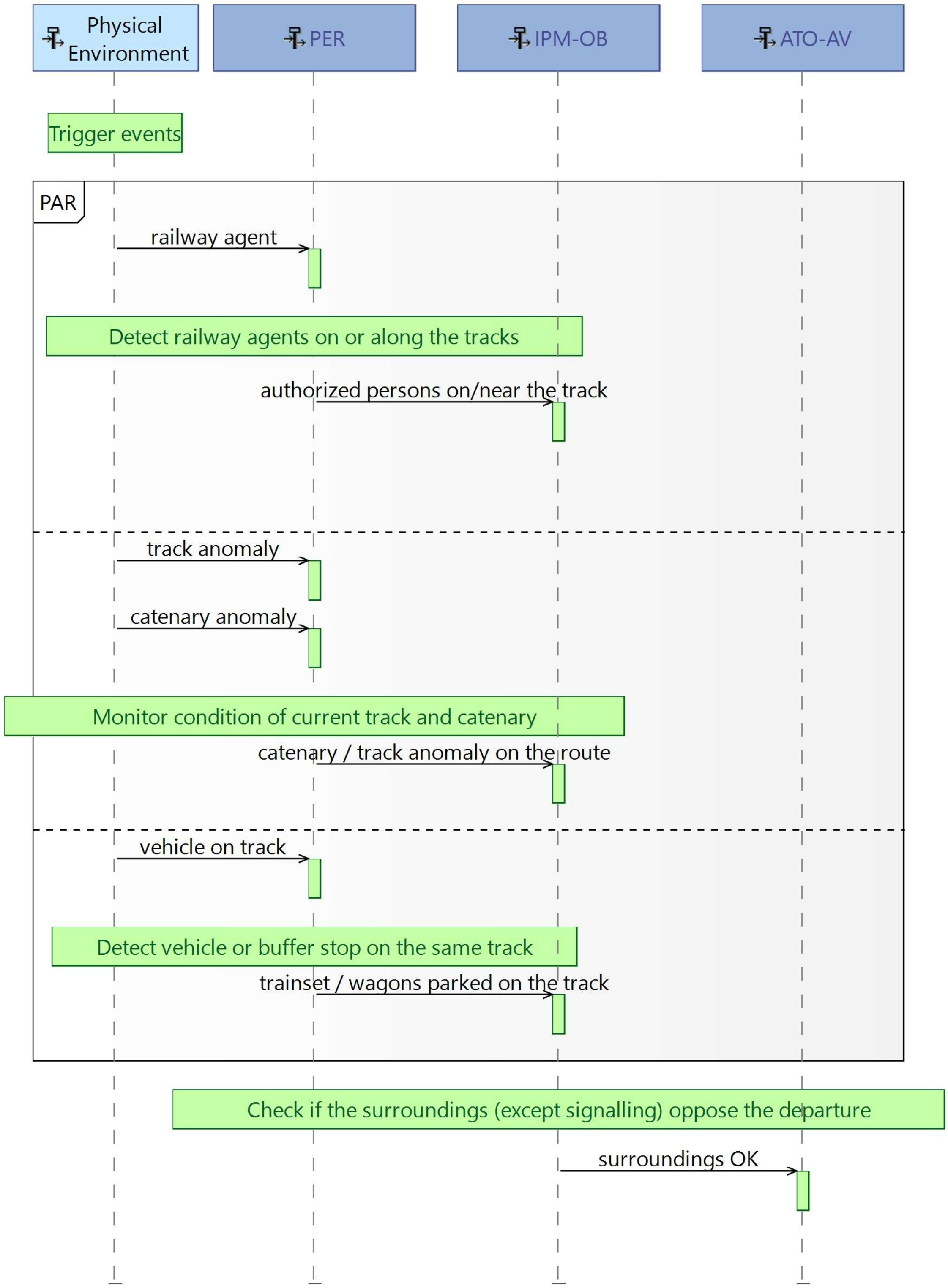
### 12.4.1 Move autonomous train

This Use Case describes the activities performed when a train is running.


TCMS
ATO-AV
Train Protection
Compute static and dynamic data for ATO
ETCS_ATO_Dynamic
ref
[ES] Traction and brake control
Regulate traction and braking effort
ALT
cmd traction force
G.B Provide acceleration
measured traction force
cmd brake during itinerary
G.C.F.C.D Provide Brake Command for Service Braking
G.C.F.F Acquire realised braking effort
measured brake force

### 12.4.2 Check departure conditions except signalling

This Use Case details the specific checks performed by the sensors before to authorize the departure of a train.




### 12.4.3 Test brakes dynamically

This Use Case describes the test of the brakes while a train is running.

Description

Dynamic tests of the brakes by ATO are necessary for performance reasons. If the brakes are not efficient, an incident must be reported via IPM because it will impact the operation. Safety is ensured by ETCS that will intervene if the most restrictive braking curve is crossed.

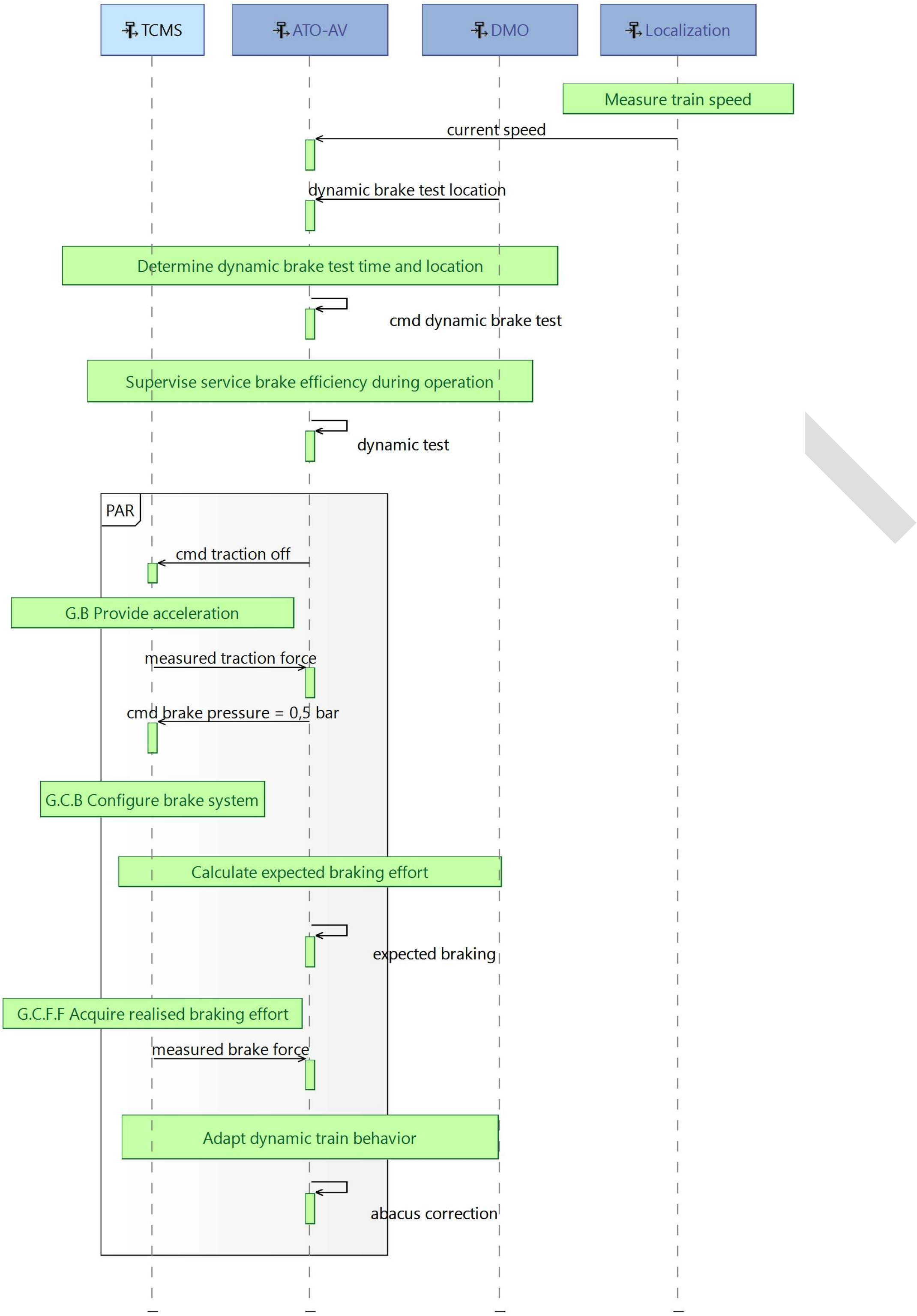
The criteria to test the brakes are different for passenger and freight trains. For passenger trains, the brakes are tested regularly thanks to the station stops and ATO will disengage in case of anomaly, but a long coasting distance or specific environmental conditions affecting the braking system could imply more regular brake tests. Freight trains are running on longer distances before to brake and additional tests are required for testing them regularly or at specific locations like before a downhill.

The dynamic brake test does not require to stop the train, a slowdown from 100 to 80 km/h could be enough for example. A test at regular interval is a solution but it does not replace the test at specific locations for downhill. The location to test the brakes should be part of the SP and managed by ATO for execution by TCMS.

The dynamic brake test should not be initiated by TCMS because it could enter in conflict with a traction request from ATO. The feedback of the effective deceleration should be given by the LZ logical component.

Reaction of ATO on a failed brake test is managed by IPM-OB («Define driving action depending on incident» function):
- If the brake failure is not severe (define a minimal brake percentage which is necessary to continue the journey): continue journey with reduced brake percentage. IPM-OB reports failed brake issue to IPM-ISM.
- If the brake failure is severe: reduce speed and stop at the next evacuation point. Organise an assistance / rescue train and/or maintenance of the train. IPM-OB reports failed brake issue to IPM-ISM.

Note: this dynamic brake test is not foreseen for de-icing the electro-pneumatic brakes (different procedure).




### 12.4.4 Manage headlights

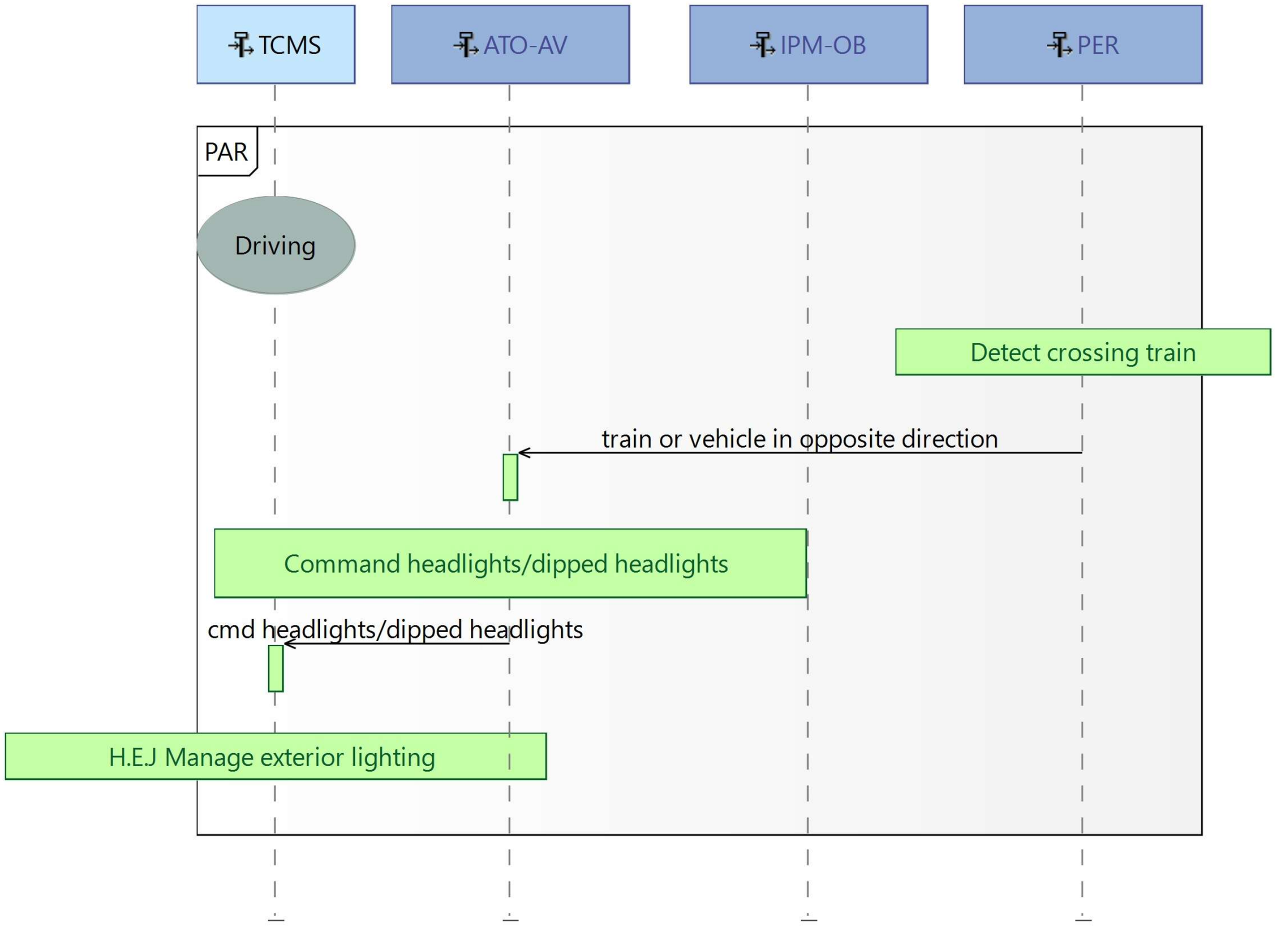
This Use Case details the conditions for activating headlights.

Description

Headlights are managed by TCMS but a switch to dipped headlignts is controlled by ATO-AV with the following conditions:

- a crossing train is detected (dynamic)

- train is approaching an area where dipped headlights are required like in the vicinity of an adjacent road for avoiding car driver blinding (static). A track condition associated to dipped headlights should be part of DMT.




### 12.4.5 Activate horn

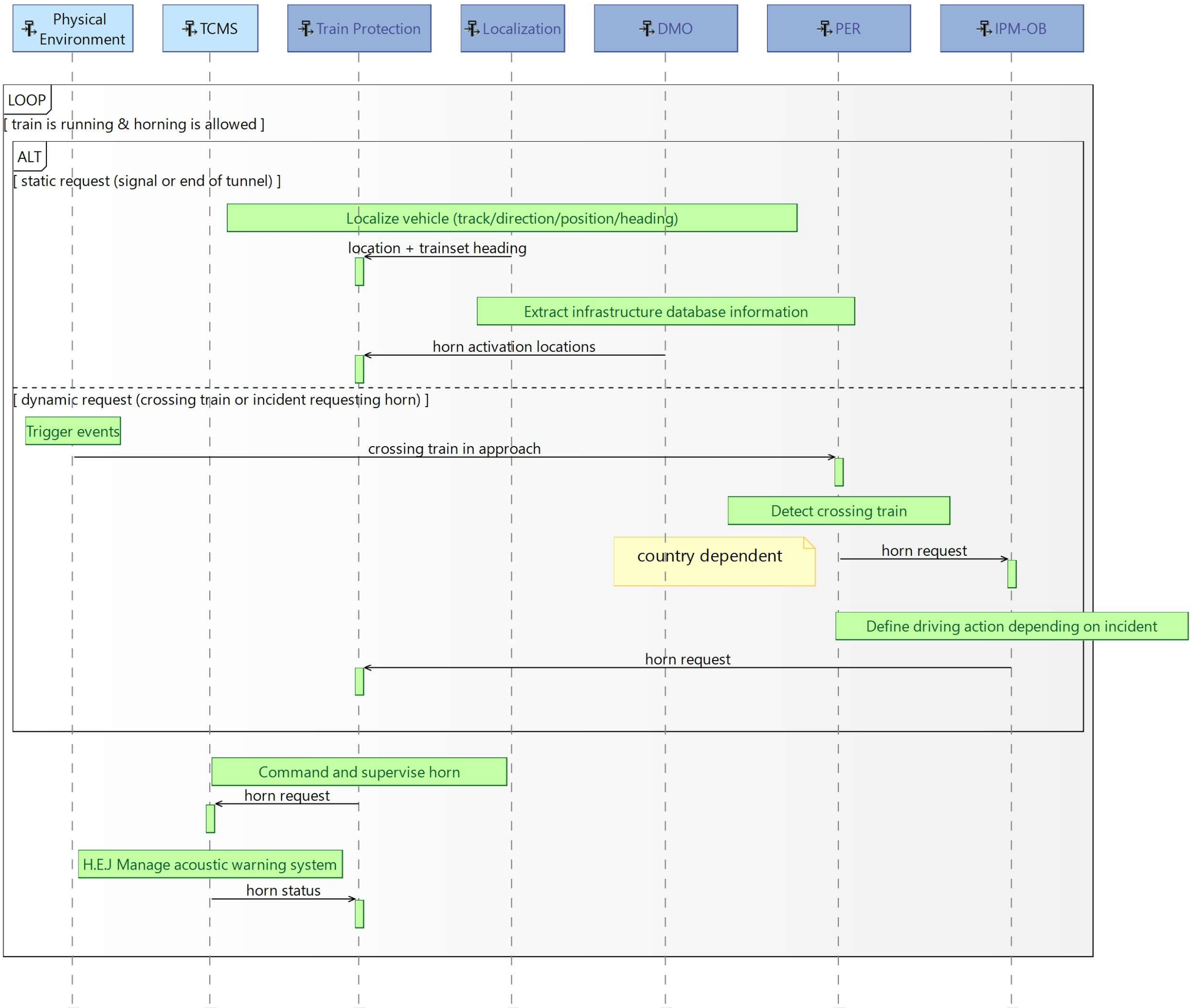
This Use Case details the conditions for horn activation.

Description

Horn should be activated at predefined locations or following a dynamic event:

- static : action on DMI from ETCS should be replaced with an action on the horn that is safety

related (at least for GoA34).
- dynamic: current allocation is Train Protection but to be confirmed by safety analysis, it could be IPM-OB.




### 12.4.6 Cut current, lower and change pantograph

This Use Case details the conditions for managing the pantograph.

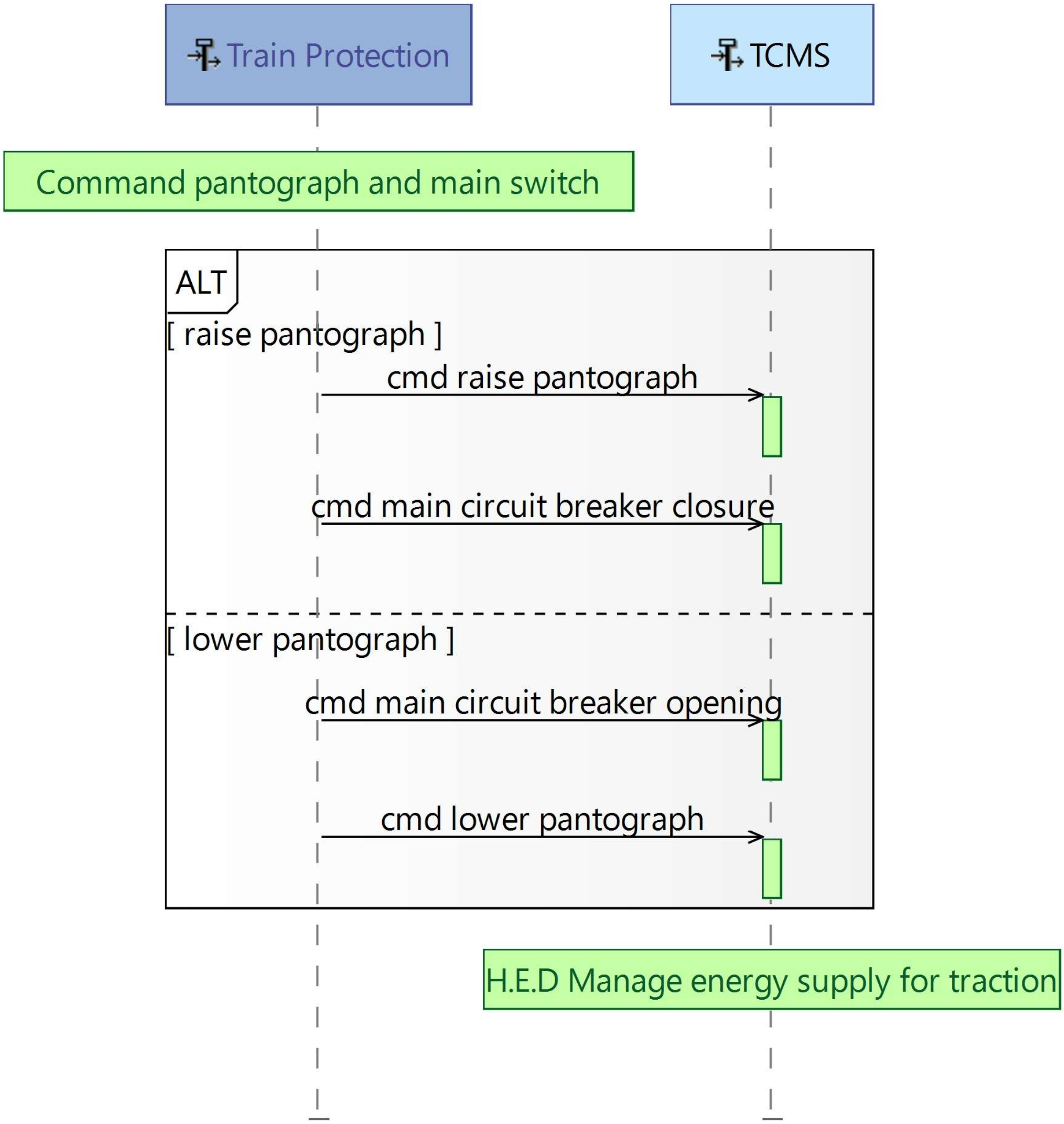
Description

Main switch and pantograph are controlled by Train Protection with track conditions during train run. During awakening and shutdown of the train, it is performed by TCMS.

During awakening, the Train Unit connects to the catenary by raising the pantograph and closing the main switch.

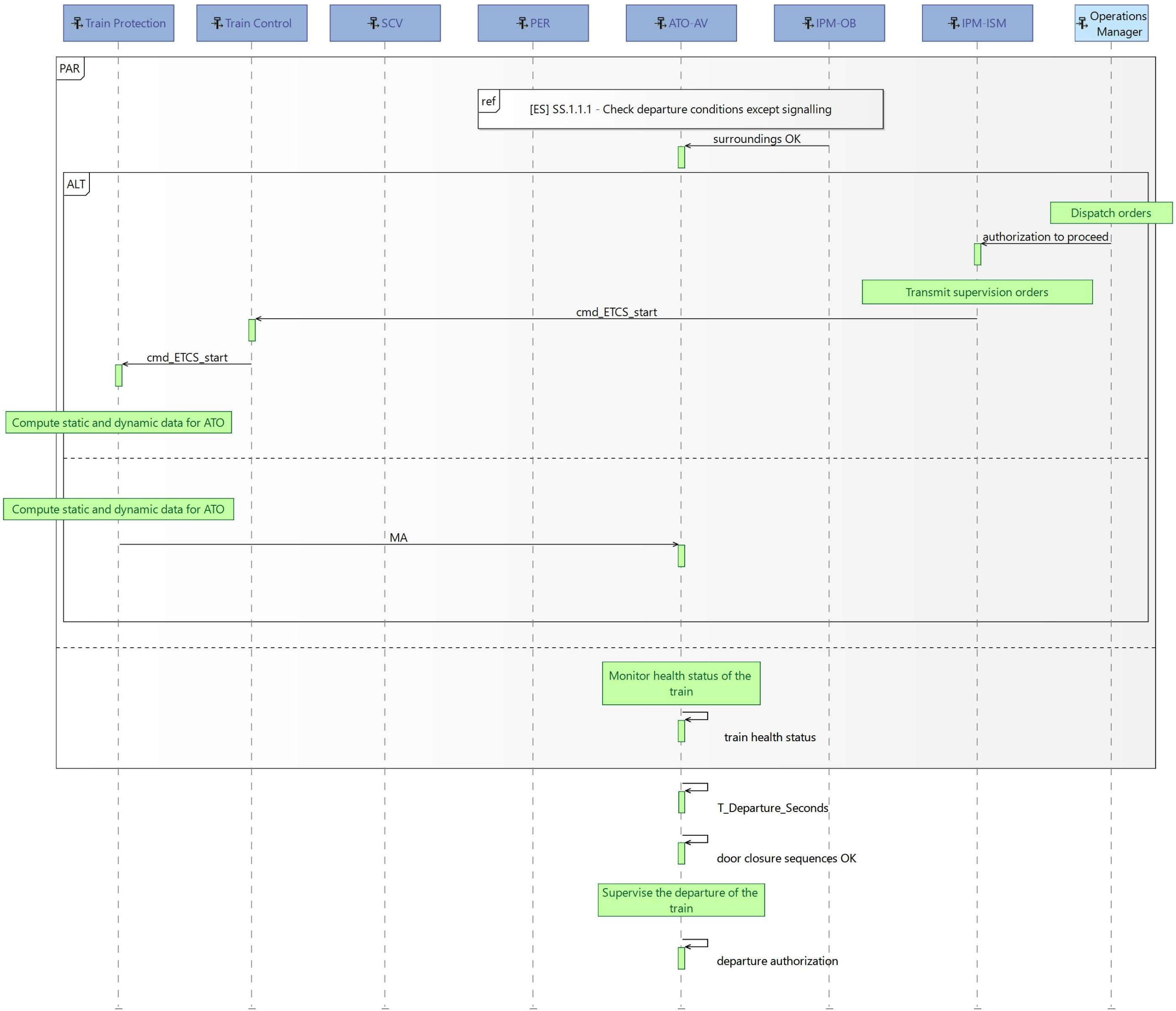
During shutdown, the Train Unit disconnects from the catenary by opening the main switch and lowering the pantograph.

Note: Stationary traction system switch is a particular case in some countries (several cases in Germany, one case in the Netherlands that will be replaced because such system is expensive). A solution based on ETCS and TCMS does not seem possible for this case but considering that the train is at standstill in such station, a change of traction system ordered by ATO is recommended.




### 12.4.7 Authorize departure of autonomous train

This Use Case describes the specific checks associated to the departure of an autonomous train.




## 12.4.8 Determine stopping point for a freight or passenger train

This Use Case is dedicated to the determination of stopping points.

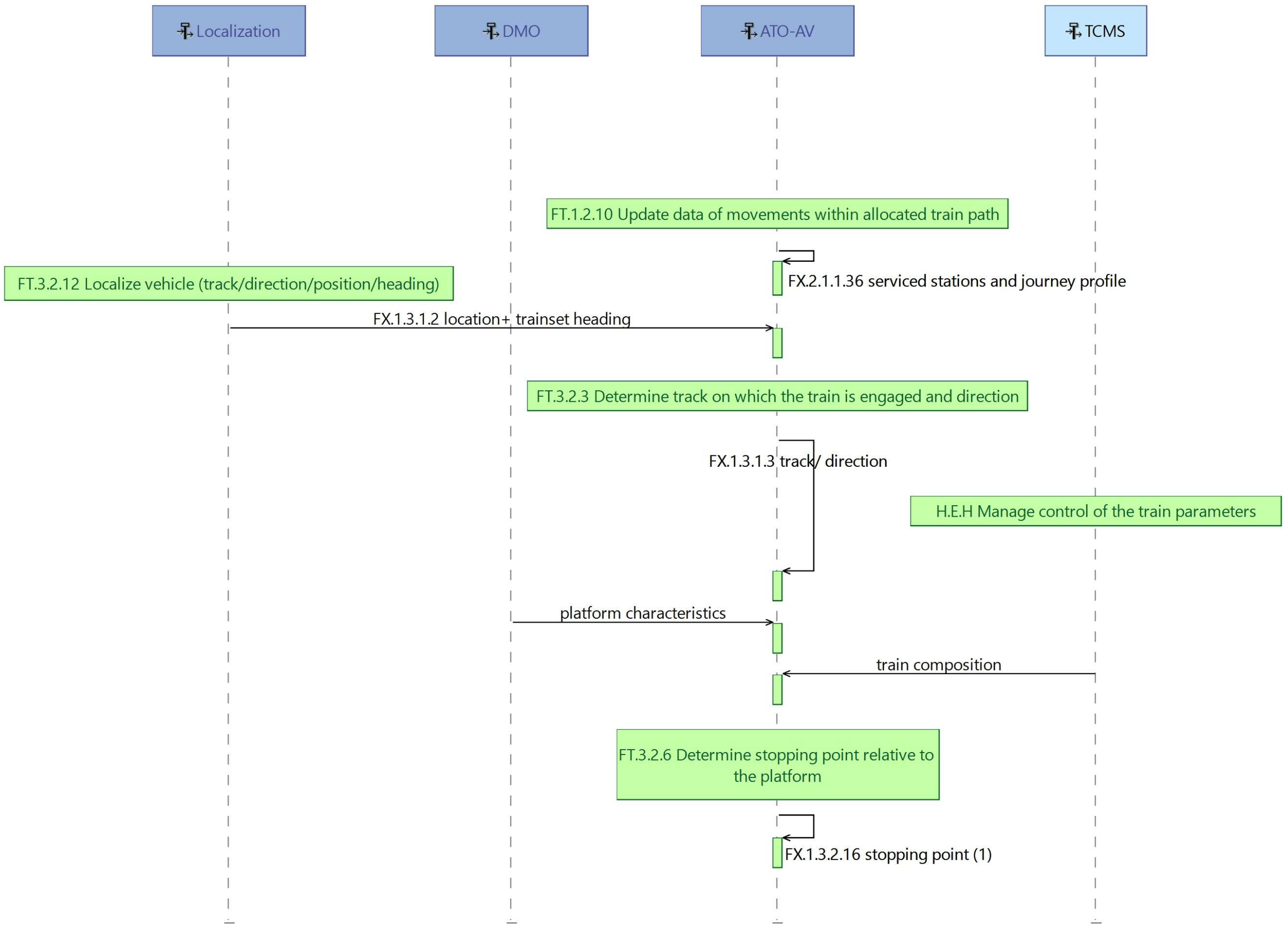
Description

A train movement follows the itineraries set by TMS. A change of itinerary must be followed by an update of JP. It is also possible to know in advance the possible itineraries and apply strategies such as optimizing the traction commands to be on time whatever next platform will be.

This feature can be useful on ETCS lines in case of loss of communication (no JP update) by taking into account several list of balises to avoid that ATO disengages like currently in Goa2. This new feature can be implemented in SS-126 by adding a link between a station and its different platforms.

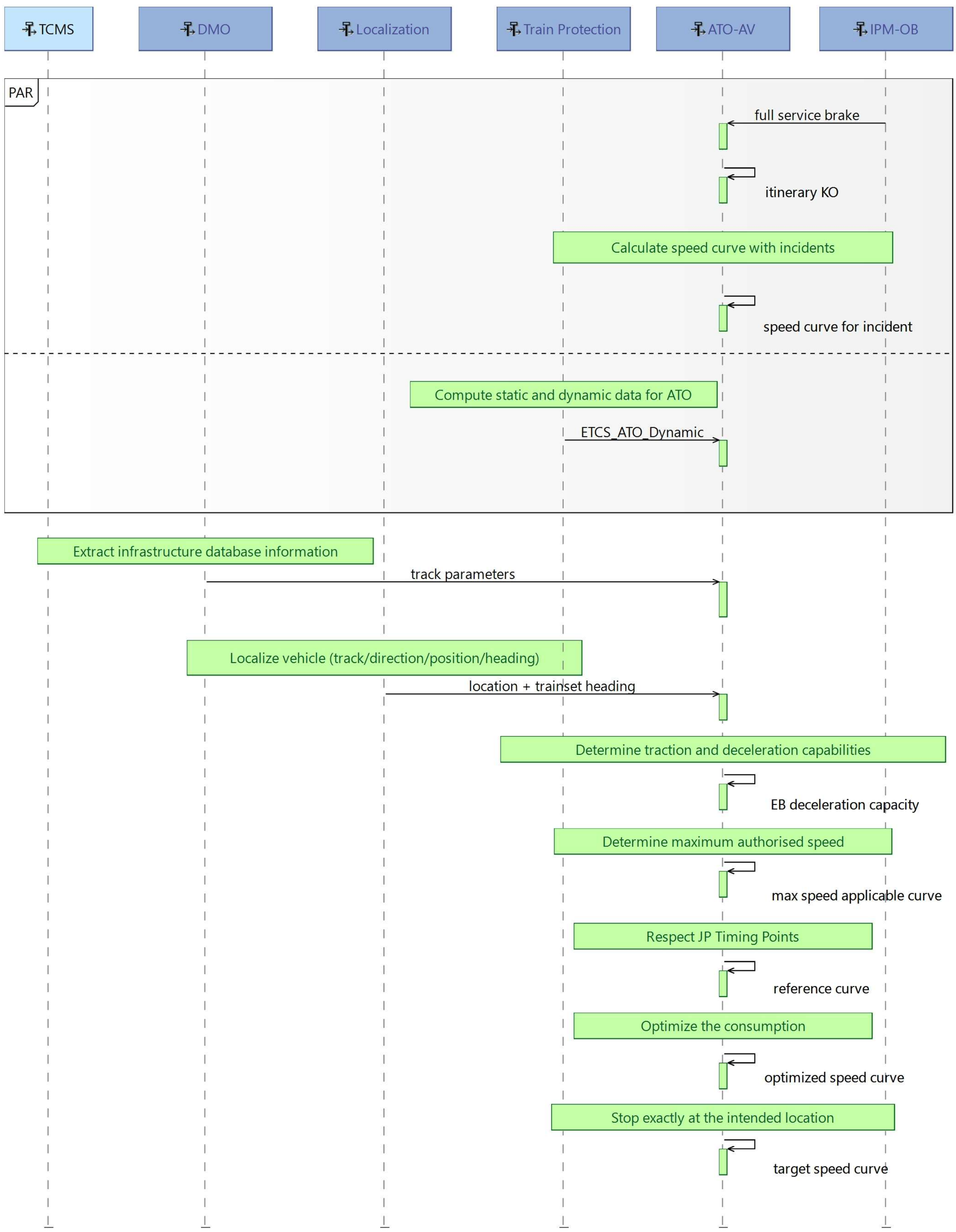
It is required for Class B when signalling information does not permit to identify the platform associated to a station entrance signal (see «Calculate all possible itineraries» and Tauro project).

Stopping points are defined in the JP.




### 12.4.9 Traction and brake control

This Use Case describes the different algorithms used by ATO while train is running.



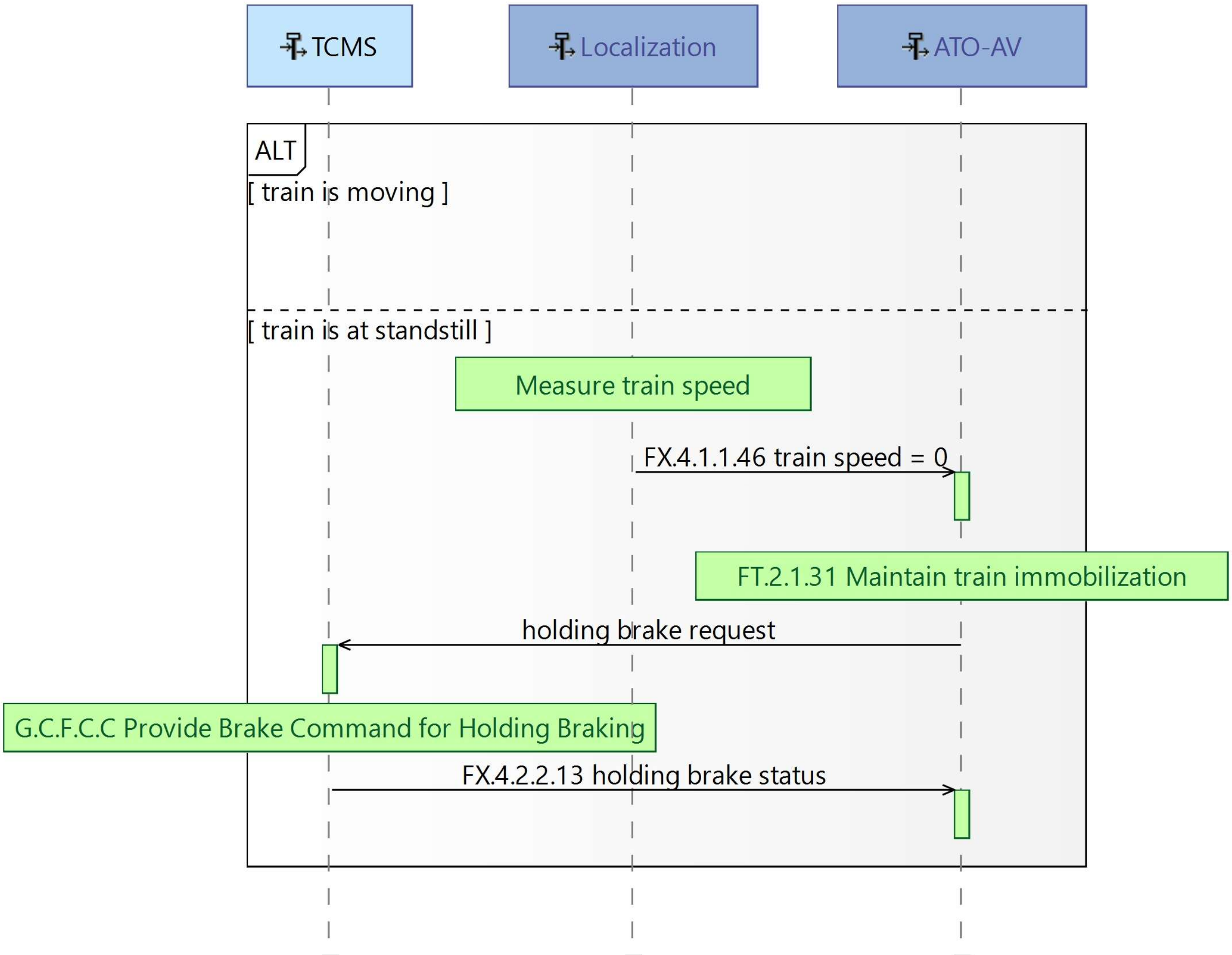

### 12.4.10 Maintain train immobilization

This Use Case is dedicated to the holding brake.

Description

The function «Maintain train immobilization» does not apply HB, but requests HB. For some trains HB is applied automatically by TCMS when conditions are met.

HB release is done by TCMS as soon as traction is applied.



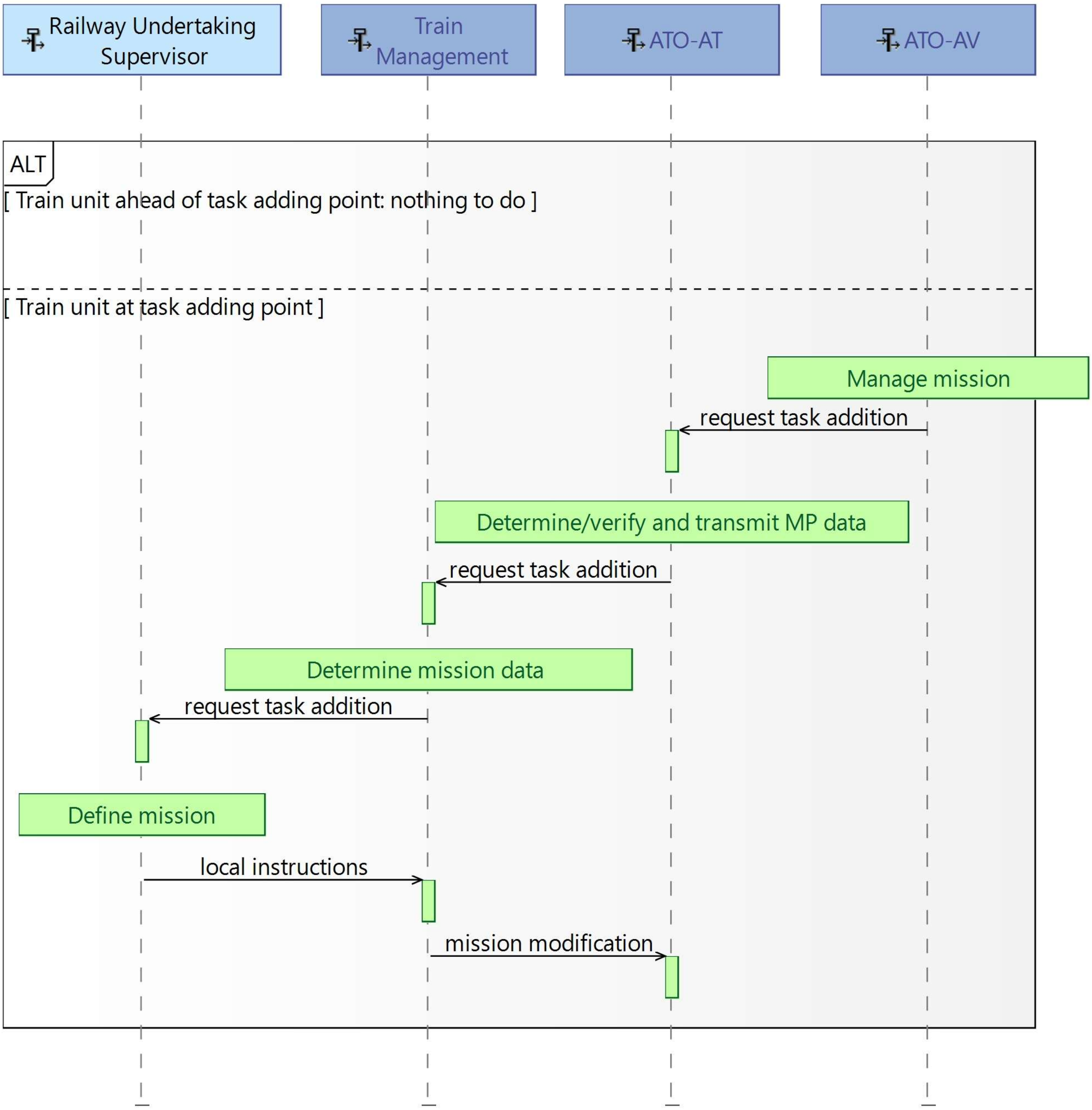

## 12.5 Other tasks

### 12.5.1 Add local tasks during mission for movements in station

This Use Case describes how to refine a mission with "empty" tasks to be completed during the move.

Description

The purpose of this Use Case is to permit a handover between TMS and a local TMS to do unscheduled operations between station and its garage yard, or inside the station. Local TMS will set a route for the shunting movement and its associated ATO-AT will send a simplified JP without arrival time to reach the related target point. Main mission could remain as such, TMS will set a route for the main movement at scheduled time or will adapt the JP in case of delay.

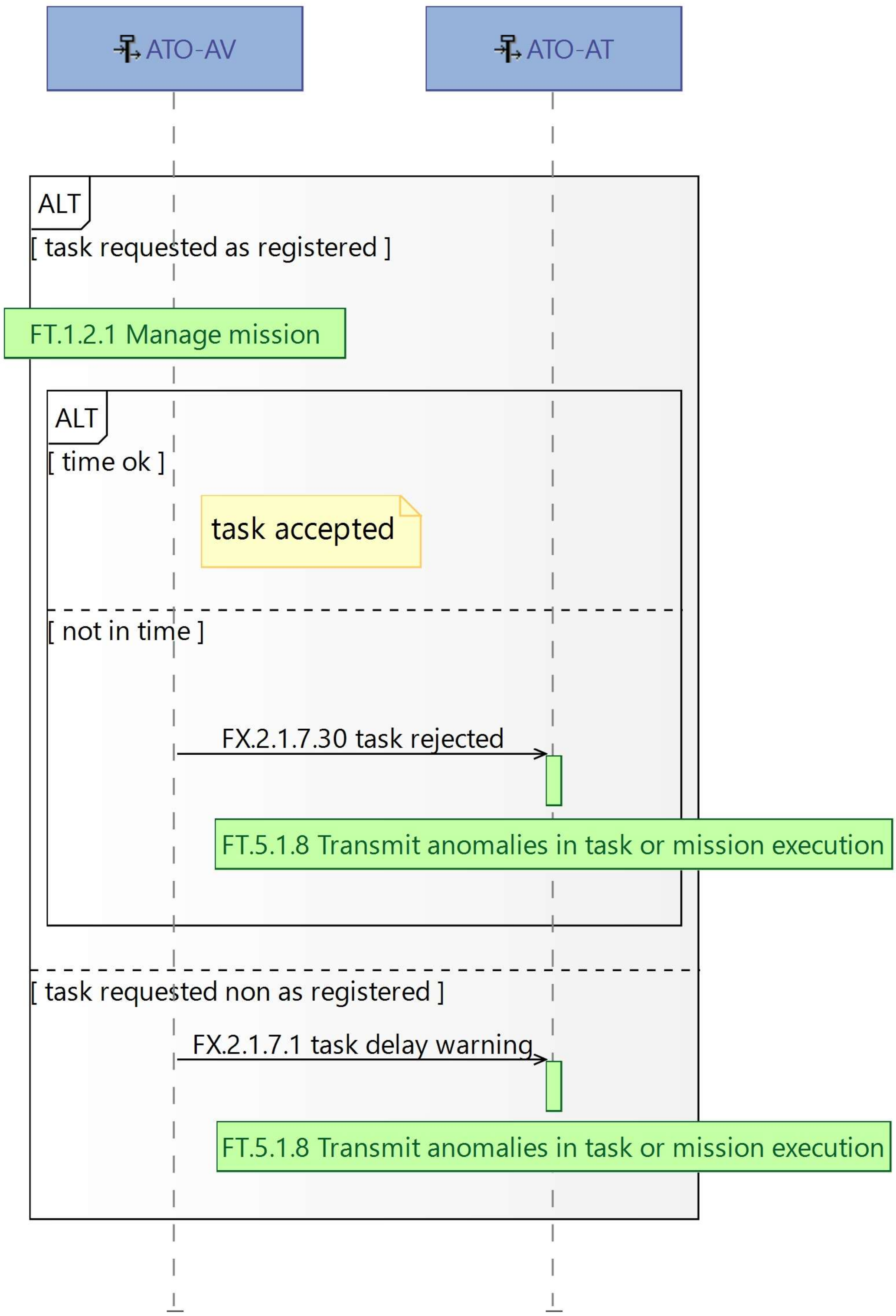



### 12.5.2 Validate human interaction

This Use Case describes the use of planned time slots to authorise or forbid human intervention.

Description

ATO-AV executes the tasks defined in the mission like a sequencer. Train Preparation Staff interventions are only authorised during planned time slots and Manage mission supervises the execution in background: task is accepted, rejected or a delay in execution is transmitted.


ATO-AV
ATO-AT
ALT
[ task requested as registered ]
FT.1.2.1 Manage mission
ALT
[ time ok ]
task accepted
[ not in time ]
FX.2.1.7.30 task rejected
FT.5.1.8 Transmit anomalies in task or mission execution
[ task requested non as registered ]
FX.2.1.7.1 task delay warning
FT.5.1.8 Transmit anomalies in task or mission execution

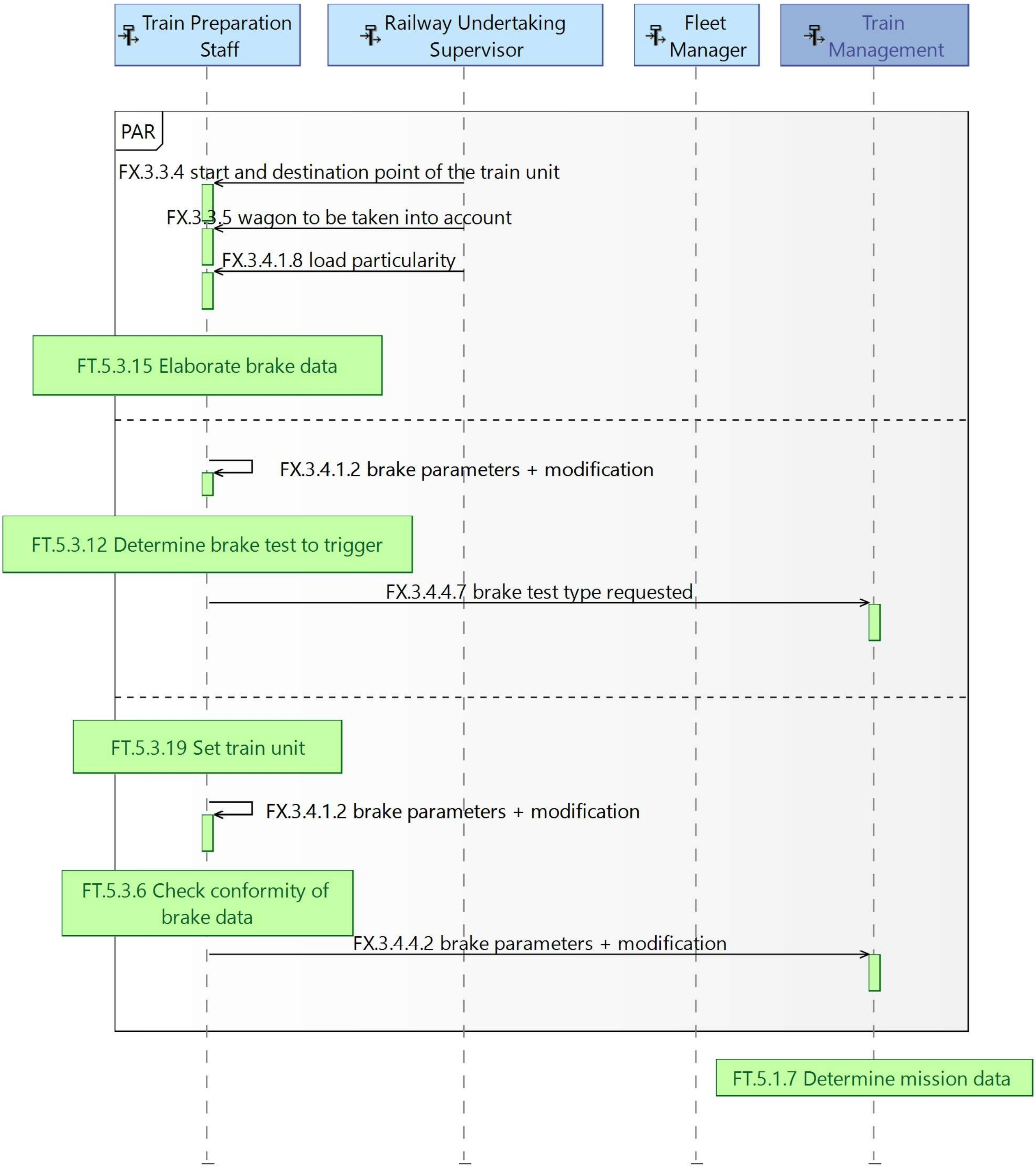
## 12.6 Freight train scenarios

### 12.6.1 Prepare freight train

This Use Case focuses on freight train preparation.

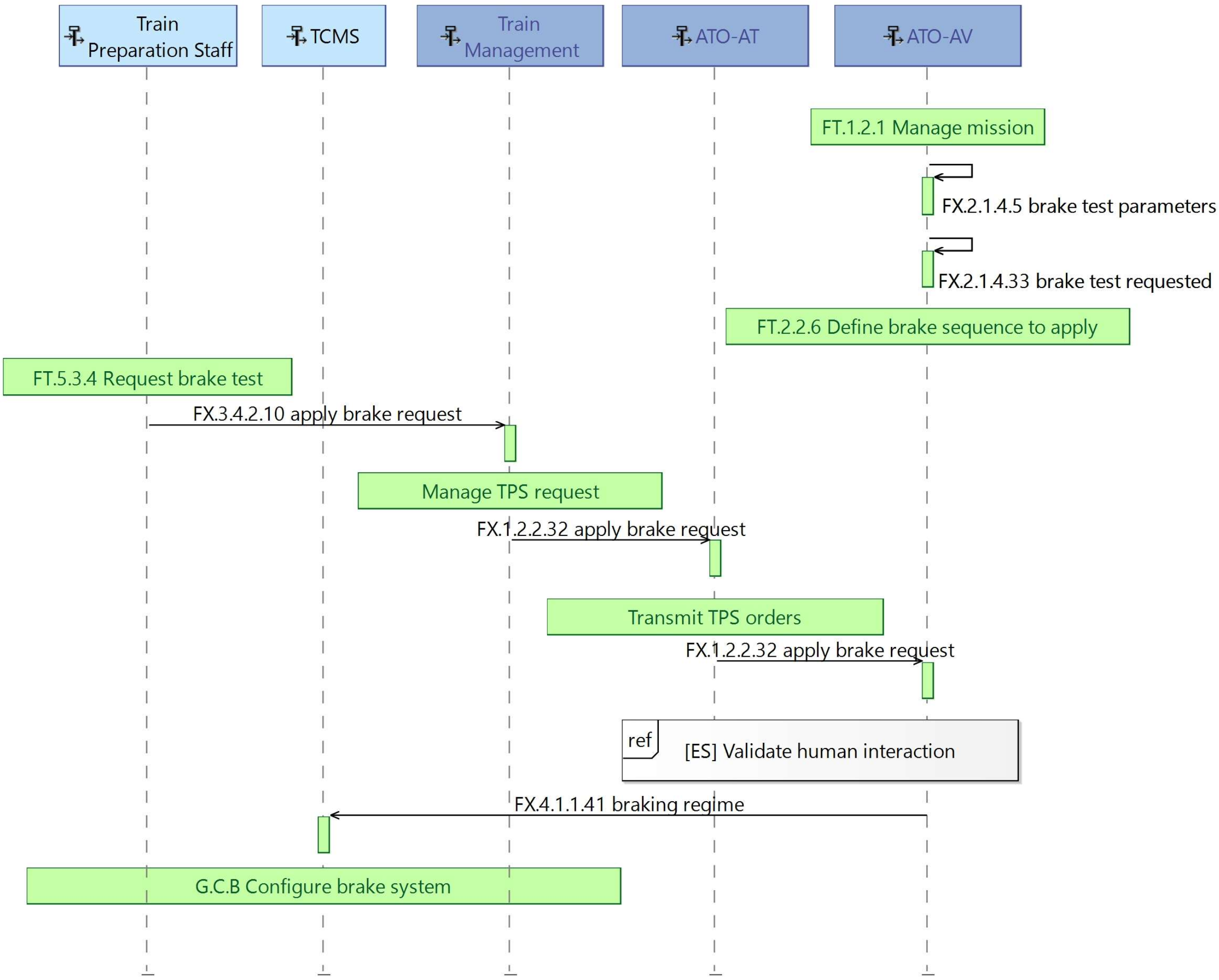
Description

This Use case describes the interactions between TPS and the freight train in absence of Digital Automating Couplers.




## 12.6.2 Start a brake test (freight)

This Use Case describes the initialization of a brake test requested by train preparation staff.




### 12.6.3 Coupling of a loco (freight)

This Use Case describes the activities associated to the coupling of a locomotive with the support of Train Preparation Staff.

Description

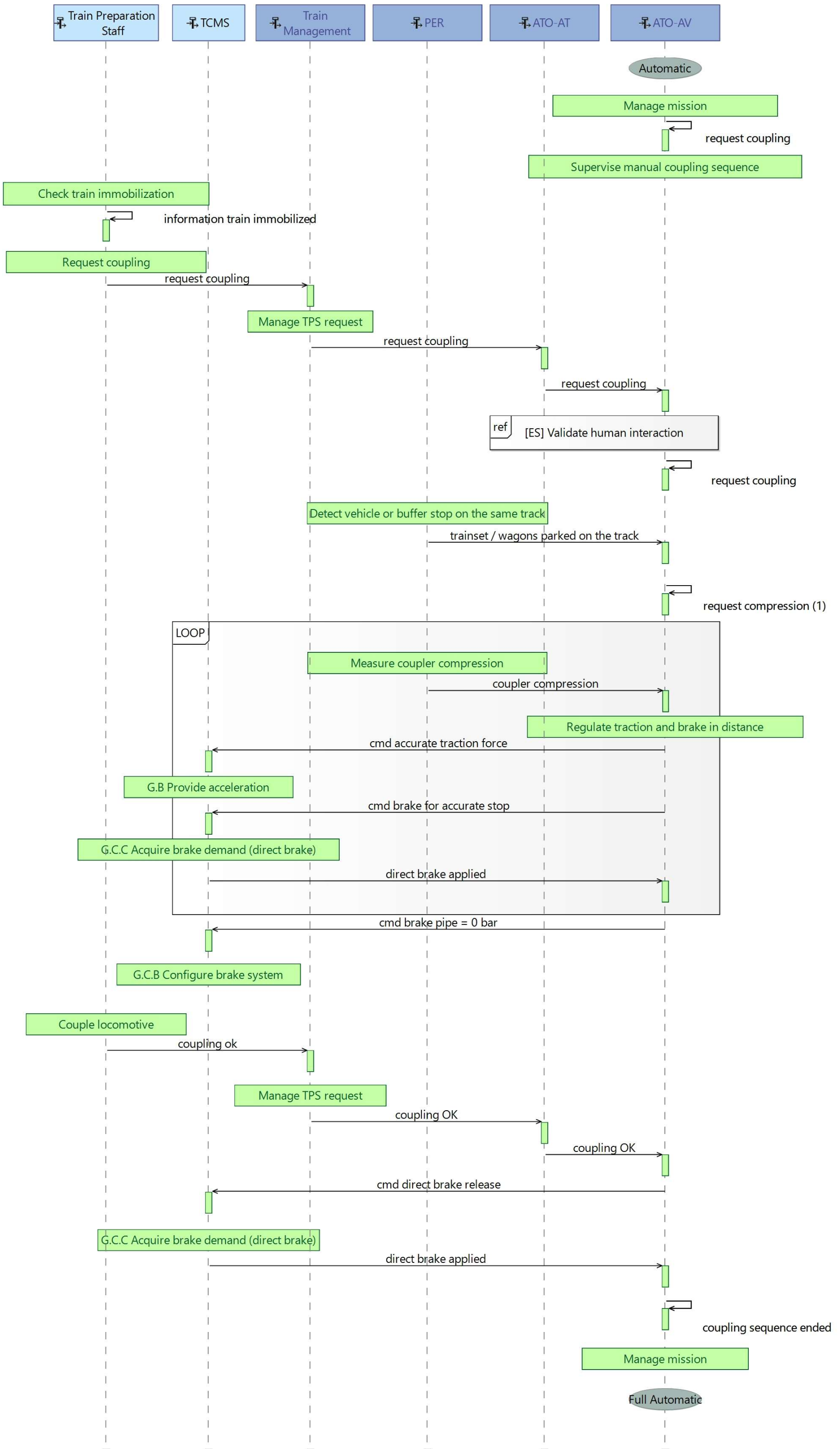
Train Preparation Staff takes control of the train after a handshake process with Train Management through C45. GoA34 mission is interrupted until confirmation from TPS that coupling is done. The staff operation can be assisted by GoA34 system in an elaborated solution (via the entry in a specific operational mode** with specific sensors to detect the compression, see «Measure distance between loco and wagons») or limited to a remote driving in the simplest solution depending on the freight wagon. The local remote control should be limited to small distances (a few meters).

The train is protected by ETCS in SB mode. ETCS must be switched to SH mode when a movement is necessary.

The communication channel for remote control must be safe. Cybersecurity and delays must be considered. A loss of communication must lead to brake application. Remote driving implies a robust communication system (coverage levels are specified in UIC 951 with a coverage probability of 95 %).

A specific lamp is required on the train to inform that train is under control (autonomous mode or remote control).

**A local remote control mode could be added in ATO-AV STM to permit interactions with Train Preparation Staff via C45, C33 and SS-126 interfaces. In this mode, GoA34 PER is used to help the TPS in coupling activities. The function «Supervise manual coupling sequence» should then interact with «Determine ATO state» to enter in this state.


Train Preparation Staff
TCMS
Train Management
PER
ATO-AT
ATO-AV
Automatic
Manage mission
request coupling
Supervise manual coupling sequence
Check train immobilization
information train immobilized
Request coupling
request coupling
Manage TPS request
request coupling
request coupling
ref
[ES] Validate human interaction
request coupling
Detect vehicle or buffer stop on the same track
trainset / wagons parked on the track
request compression (1)
LOOP
Measure coupler compression
coupler compression
Regulate traction and brake in distance
cmd accurate traction force
G.B Provide acceleration
cmd brake for accurate stop
G.C.C Acquire brake demand (direct brake)
direct brake applied
cmd brake pipe = 0 bar
G.C.B Configure brake system
Couple locomotive
coupling ok
Manage TPS request
coupling OK
coupling OK
cmd direct brake release
G.C.C Acquire brake demand (direct brake)
direct brake applied
coupling sequence ended
Manage mission
Full Automatic

### 12.6.4 Uncoupling of a loco (freight)

This Use Case describes the activities associated to the uncoupling of a locomotive with the support of Train Preparation Staff.

Description

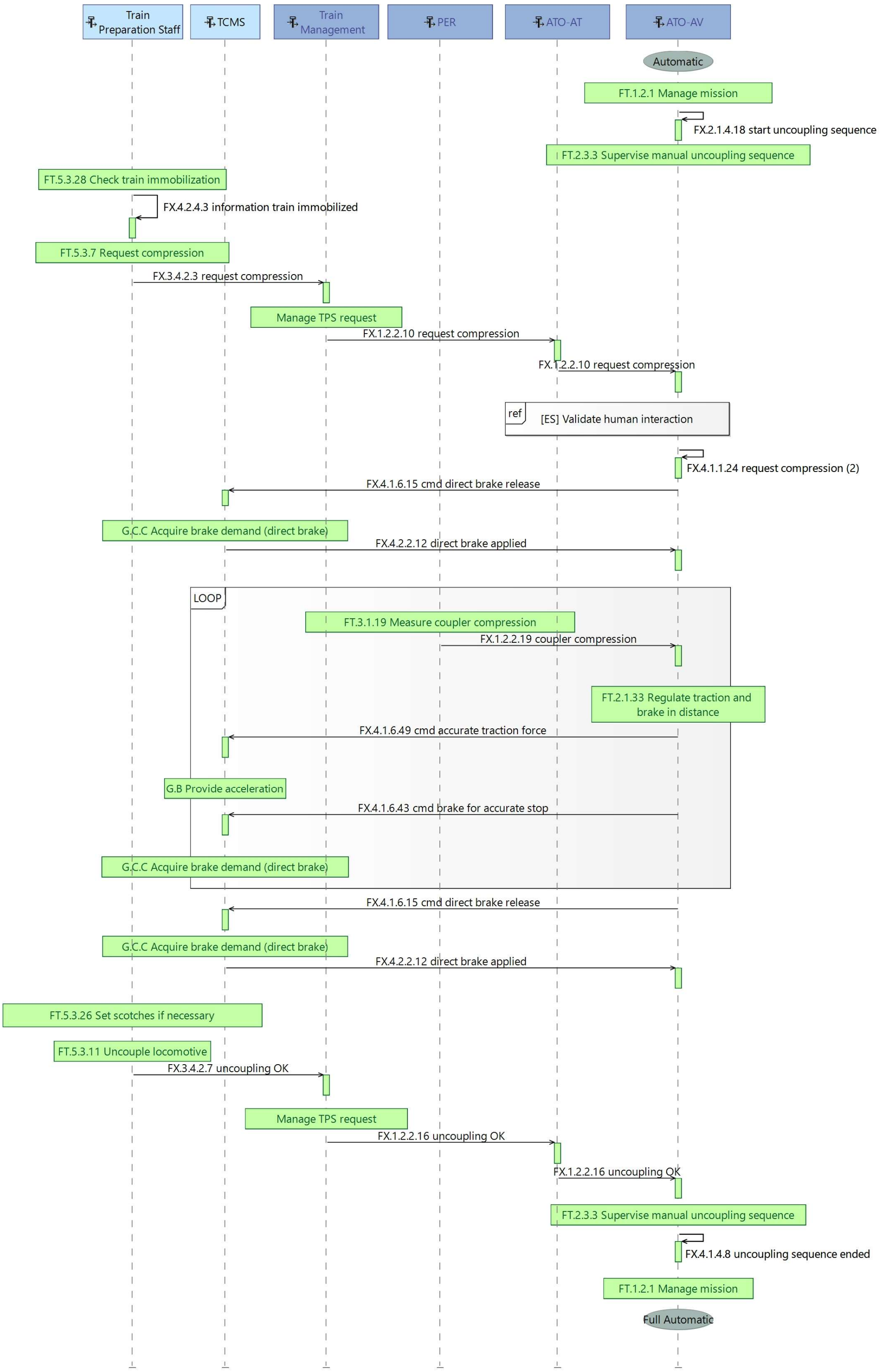
Train Preparation Staff takes control of the train after a handshake process with Train Management through C45. GoA34 mission is interrupted until confirmation from TPS that uncoupling is done. The staff operation can be assisted by GoA34 system in an elaborated solution (via the entry in a specific operational mode** with specific sensors to detect the compression, see «Measure distance between loco and wagons») or limited to a remote driving in the simplest solution depending on the freight wagon. The local remote control should be limited to small distances (a few meters).

The train is protected by ETCS in SB mode. ETCS must be switched to SH mode when a movement is necessary.

The communication channel for remote control must be safe. Cybersecurity and delays must be considered. A loss of communication must lead to brake application. Remote driving implies a robust communication system (coverage levels are specified in UIC 951 with a coverage probability of 95 %).

A specific lamp is required on the train to inform that train is under control (autonomous mode or remote control).

**A local remote control mode could be added in ATO-AV STM to permit interactions with Train Preparation Staff via C45, C33 and SS-126 interfaces. In this mode, GoA34 PER is used to help the TPS in uncoupling activities. The function «Supervise manual uncoupling sequence» should then interact with «Determine ATO state» to enter in this state.



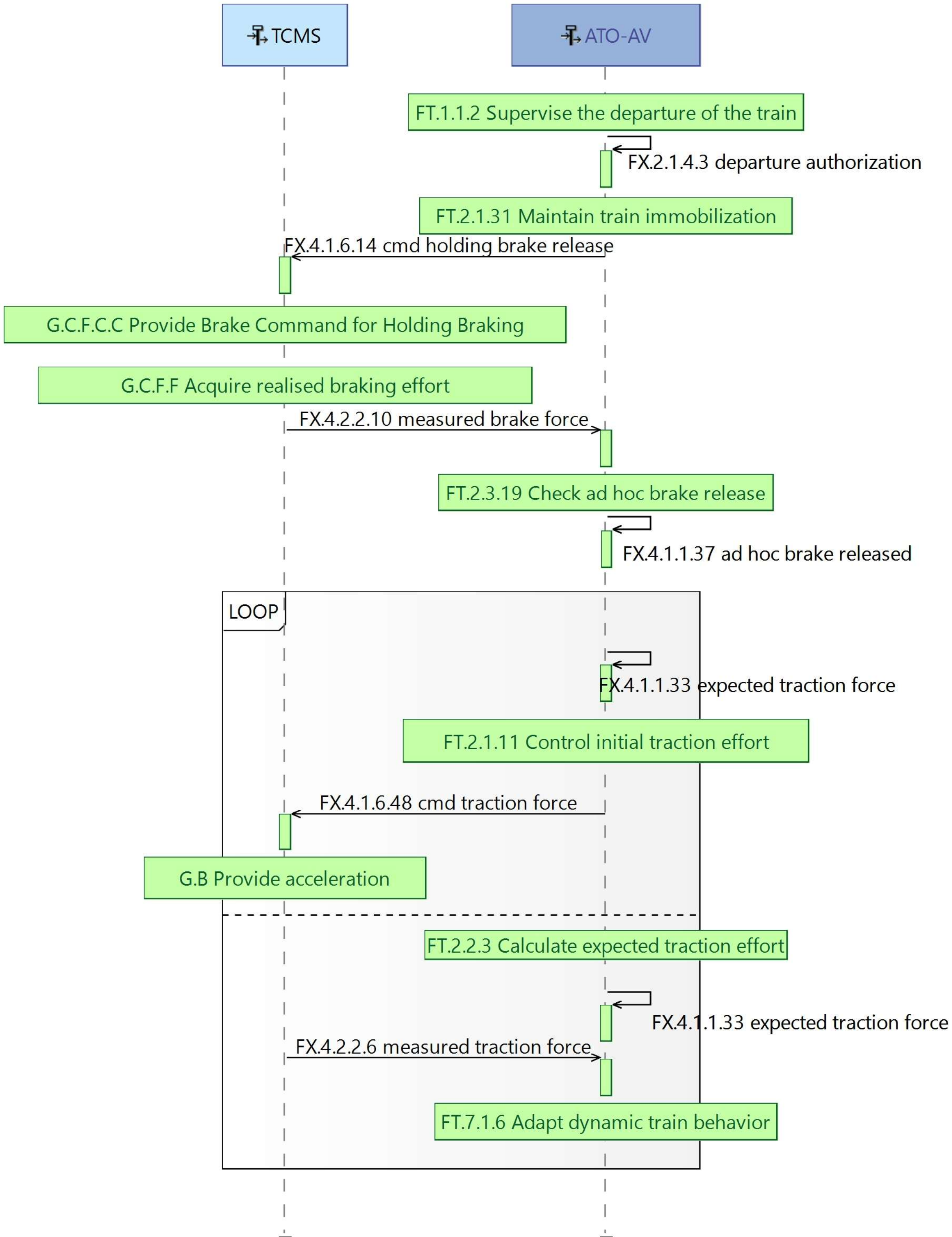

### 12.6.5 Supervise departure of autonomous freight train

This Use Case describes the specific commands associated to the departure of a freight train.

Description

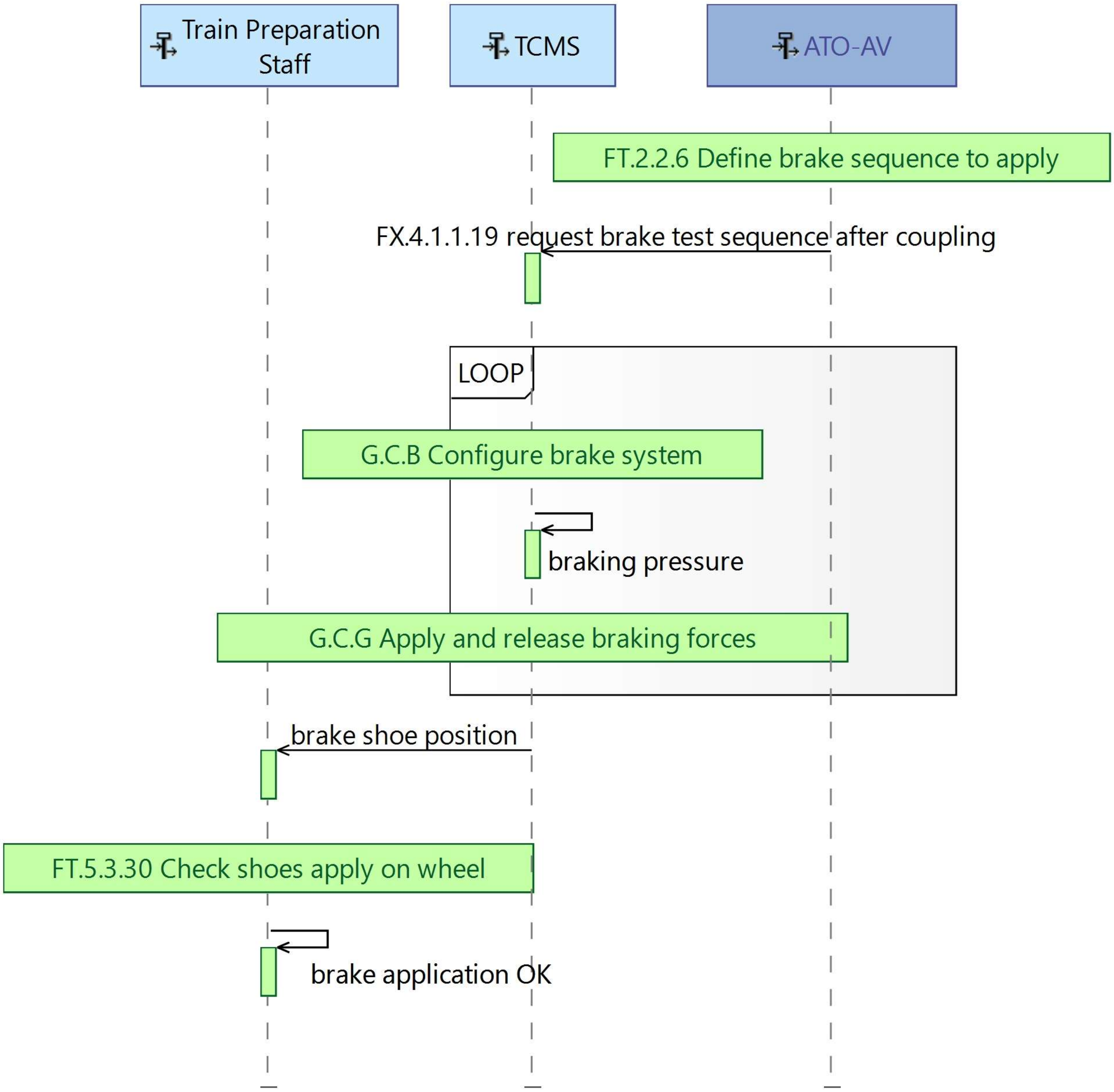
In a slope, it is expected that brake release must be progressive and combined with traction effort.

Note: hill start is part of GoA2 specifications.



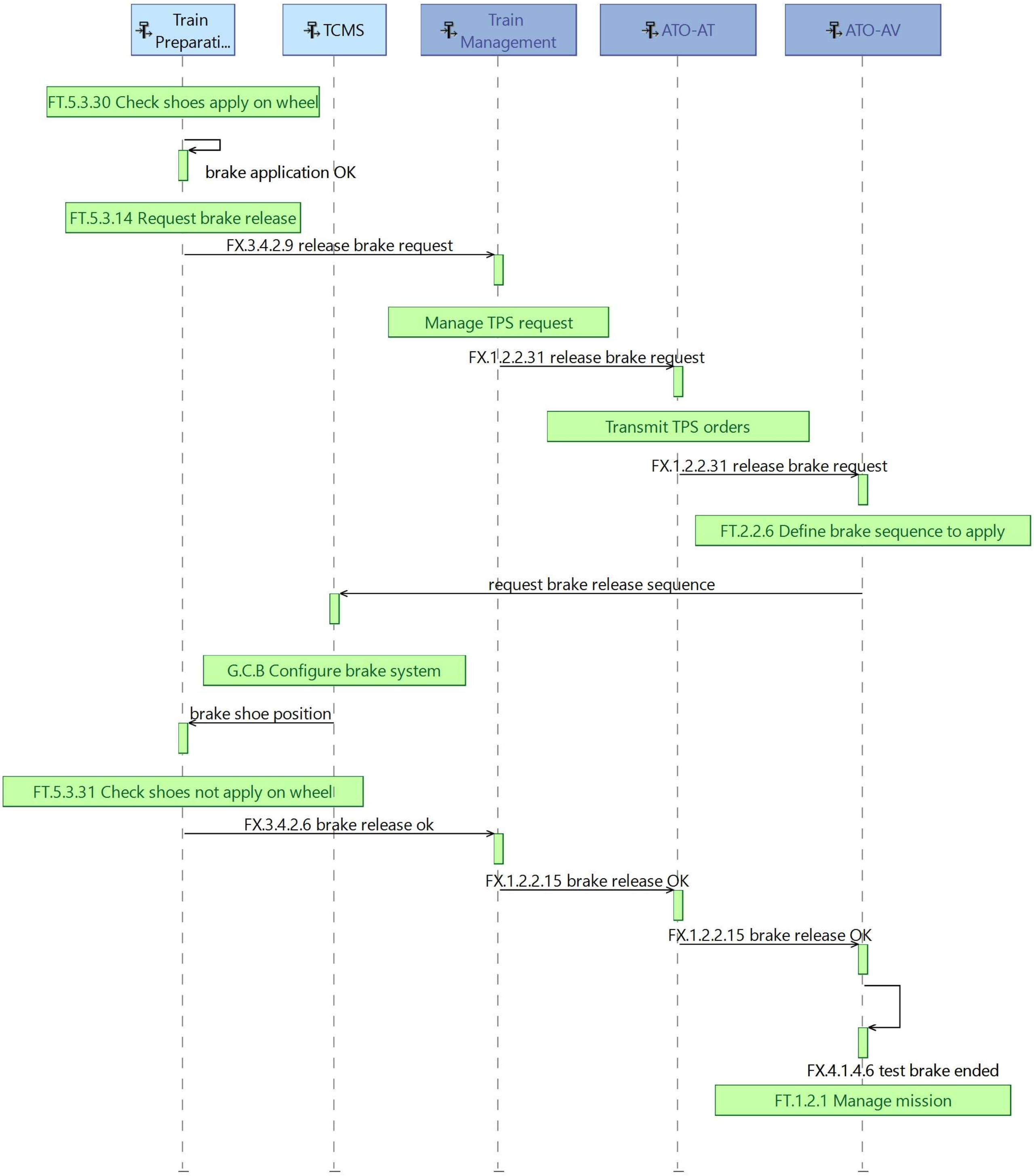

### 12.6.6 Test brake application

This Use Case describes the check of brake application with the support of train preparation staff.



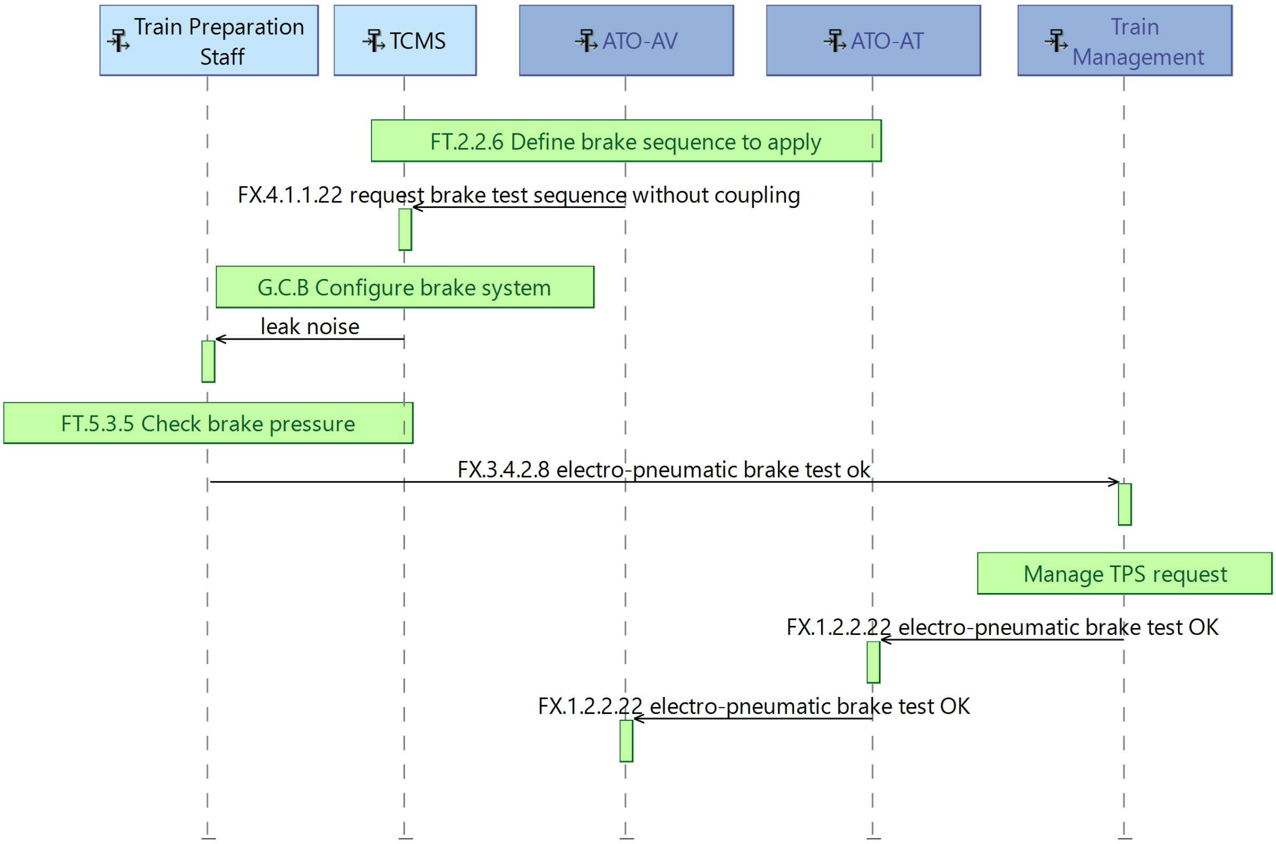

### 12.6.7 Test brake release

This Use Case describes the check of brake release with the support of train preparation staff.




### 12.6.8 Test brake pressure

This Use Case describes the check of brake pressure with the support of train preparation staff.




## 12.7 Passenger train scenarios

### 12.7.1 Manage passenger information systems

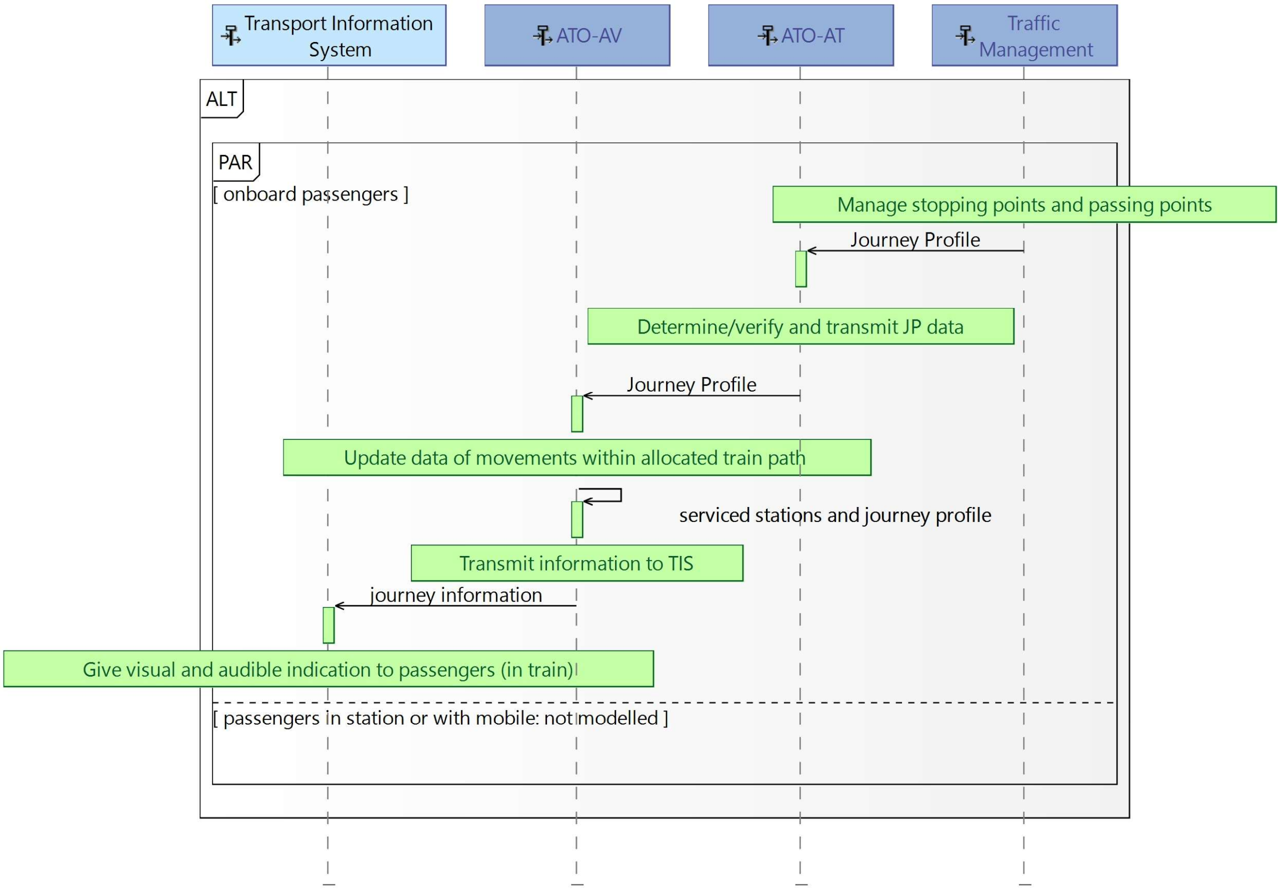
This Use Case describes the transmission of information to passengers, either on-board or in station.

Description

Journey information should be standardised (the type, not the format) with a scope limited to interoperability i.e. destination, presence in the right unit in case of multiple units, a station platform is too short, a station is skipped...

In GoA2, it is possible to have an incomplete JP. Here, for TIS, we need a complete JP. ATO-AV has to upload the full JP before to send info to TIS.

Note: Other means do exist to transmit info to TIS like a specific interface between RU and TIS but it is outside the scope of GoA34. ATO has the advantage to provide the last information: it is optional for journey but mandatory in case of incidents.




### 12.7.2 Coupling EMU

This Use Case describes an automatic joining operation of EMU.

Description

The process starts with a standing train unit stopped at the intended coupling location with holding brakes applied, continues with the transition of the moving train unit from normal running to coupling and ends when both train units are physically coupled.

The solution for joining two autonomous train units must cover two high-level functions:

- It must allow the coupling only if both train units are ready to couple; otherwise it must stop the approaching train at a defined distance in front of the standing train unit.

- It must allow the approaching train unit to travel until the coupler makes contact, even though this is not possible in regular driving in full supervision mode. This is done at a reduced speed and with the help of distance measurement (distance between approaching and standing train by perception).

The solution will be based on the following assumptions:

- The train units are equipped with automatic couplers.

- The coupling process is fully automated, no staff is involved.

- TCMS offers a coupling mode where TCMS automatically drives the train unit at coupling speed (about 1 km/h, maximum 2 km/h) until it senses physical contact of the couplers and stops the train.

- A configurable coupling distance defines the distance an approaching train shall go at coupling speed before the physical contact. This distance is at minimum as long as the train needs to reliably accelerate to coupling speed, in case its speed is 0 at the beginning of the coupling distance. We expect this distance to be typically about 5m.

- For capacity reasons the approaching train shall not travel too long at coupling speed, so not more than about 10m. An approach phase is thus necessary to cover the distance between the maximum safe front end of the approaching train and the minimum safe rear end of the standing train.

- The approaching train should not stop before making physical contact however a low coupling speed permits such stop without significant impact on performances.

- If the standing train is a passenger train, it is required that it can stand with doors open (eventually bridging plates extended, steps open) during the physical joining.

- Both trains are equipped with a TCMS or a TCMS adapter that is able to give the information whether its train unit is ready for joining.

- A configurable time defines the joining preparation activities (e.g. opening the coupler cover).

- TCMS closes the coupler cover automatically when a configurable critical speed is reached.

The coupling process includes the following steps:

- Approach of the train to be coupled with a MA provided by the signalling, either to the joint of the track section occupied by the train or to the minimum safe rear end of the train (RBC implementation to be confirmed). In both cases, the remaining distance to the train is too long for approaching the train at coupling speed.

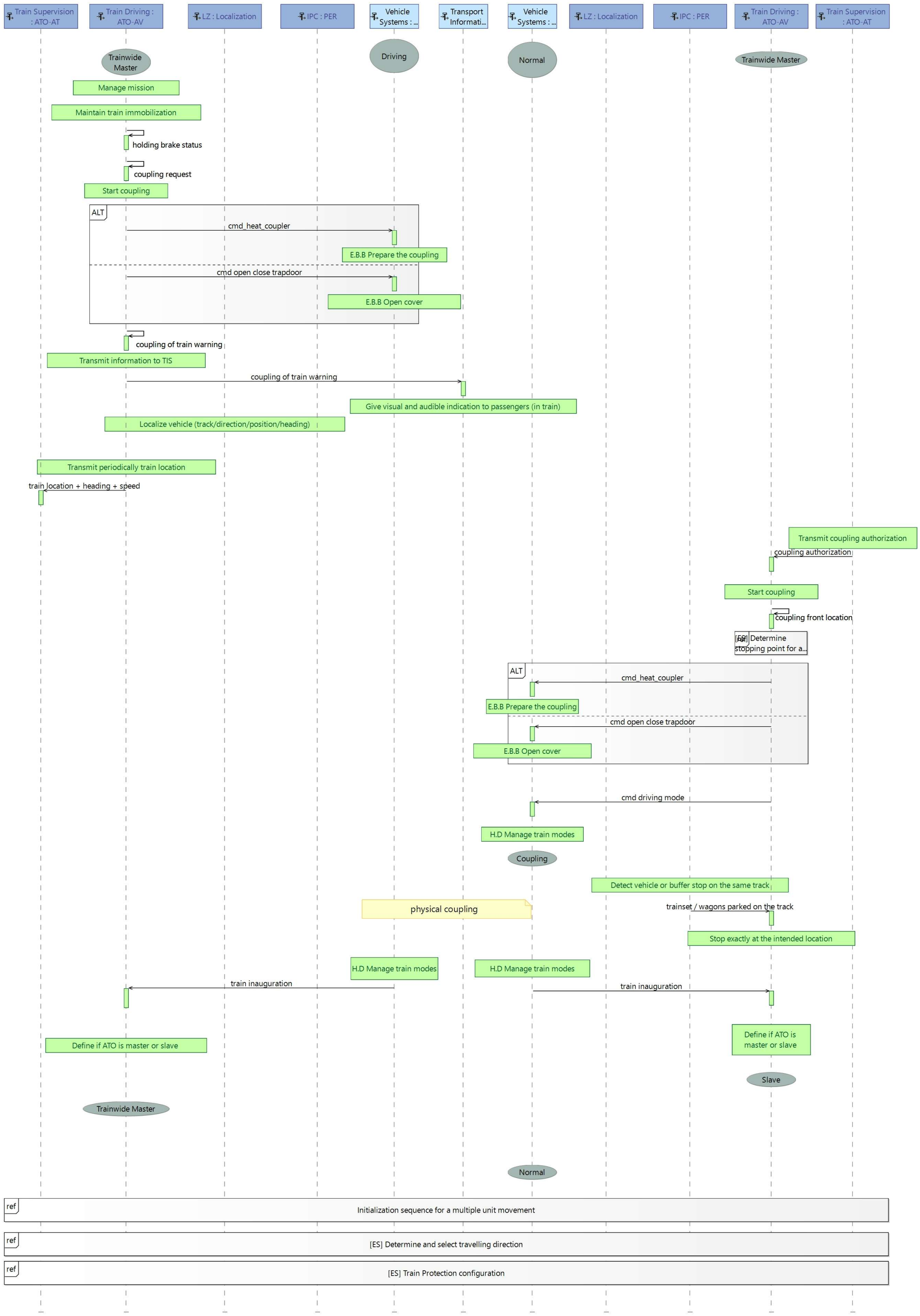
- Entering the occupied area with a specific approach mode supervised by ETCS. Current OS and SR modes permit the supervision of a maximum speed and a maximum distance however these values are too high to prevent a collision in case of ATO failure. ETCS must thus enter in a specific approach mode where it computes a braking curve associated to the distance to the target object provided by IPM-OB (train unit in case of coupling or buffer stop in case of parking).

- An acknowledgement mechanism between ETCS and IPM is proposed before to enter in approach mode. Either IPM acknowledges the transition and provides the distance to the standing train or the transition is rejected and ETCS stops the train at the end of acknowledgement area.

- ATO will drive according to that braking curve until coupling speed. It will switch TCMS to coupling mode at about 1 km/h. Coupling can be cancelled during the approach until about 5m from the target where it is still possible to stop the train.

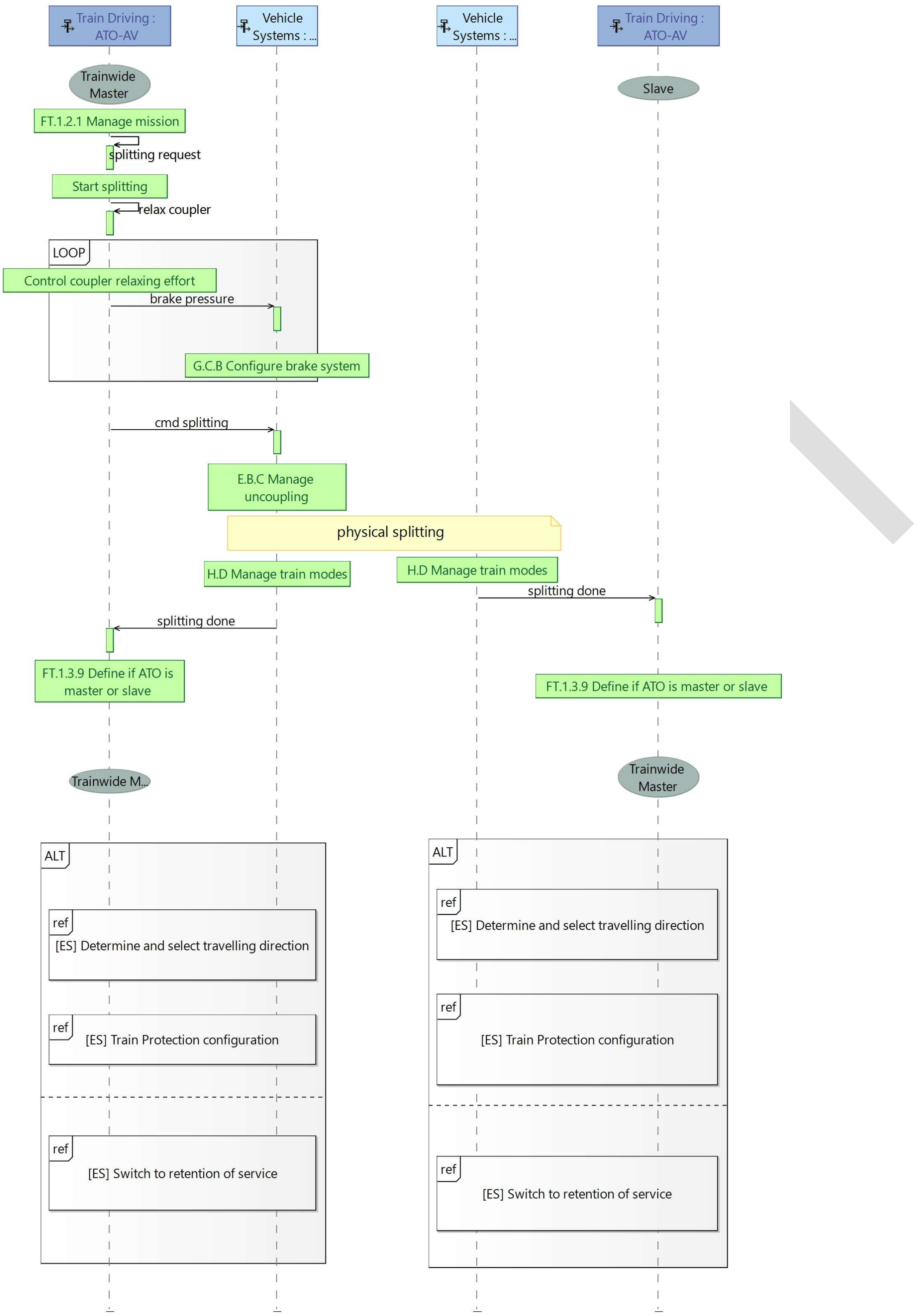
- TCMS is in charge of the last meters and drives automatically at coupling speed until physical contact where it stops the train. In coupling mode, the coupling speed is supervised by TCMS while ETCS supervises the approach mode speed (to be confirmed).

The handling of other obstacles by IPM is processed in parallel, the detection of a human on the track could lead to an emergency brake application for example.



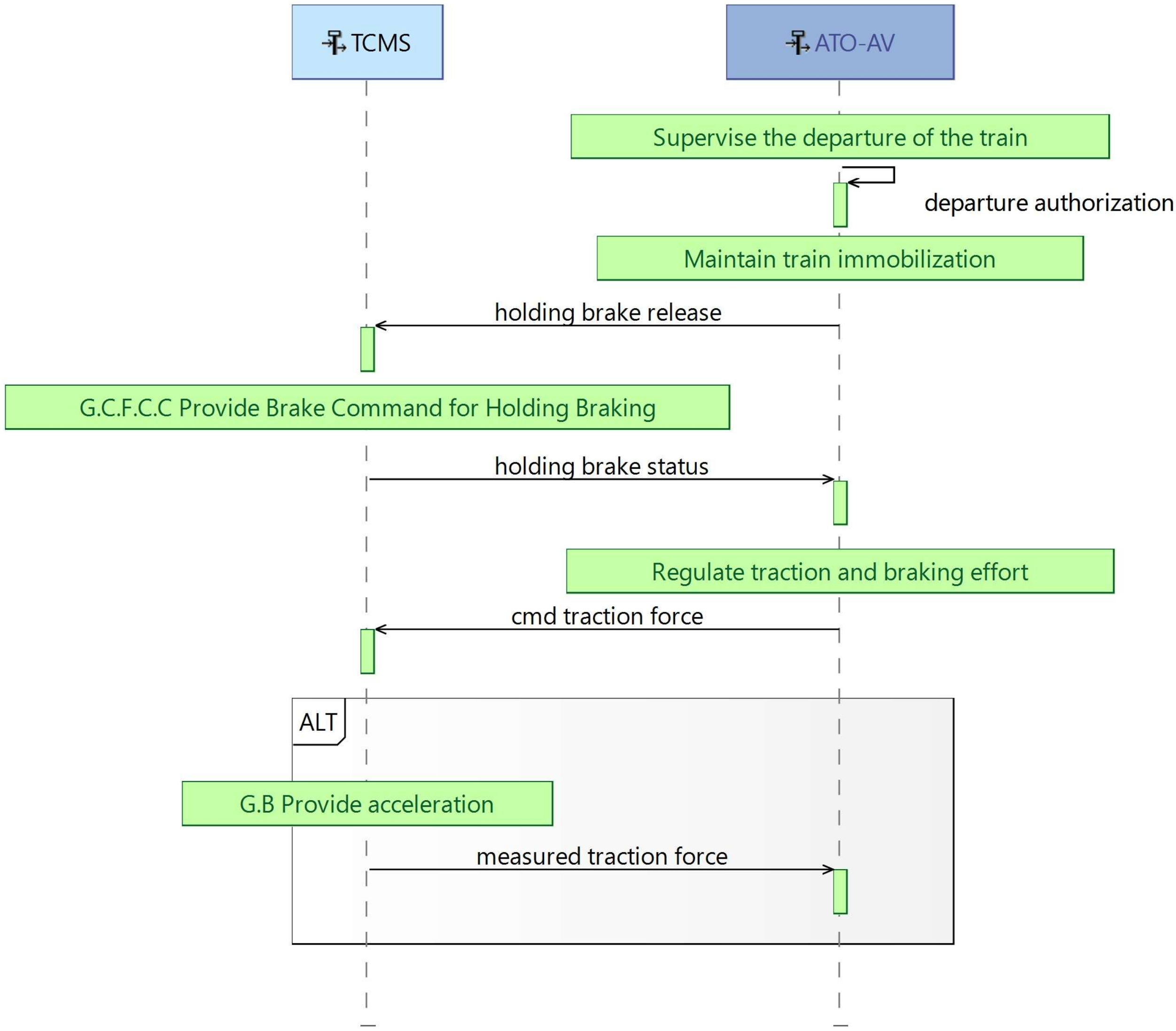

### 12.7.3 Splitting EMU

This Use Case describes an automatic splitting operation of EMU.




### 12.7.4 Supervise departure of a passenger train

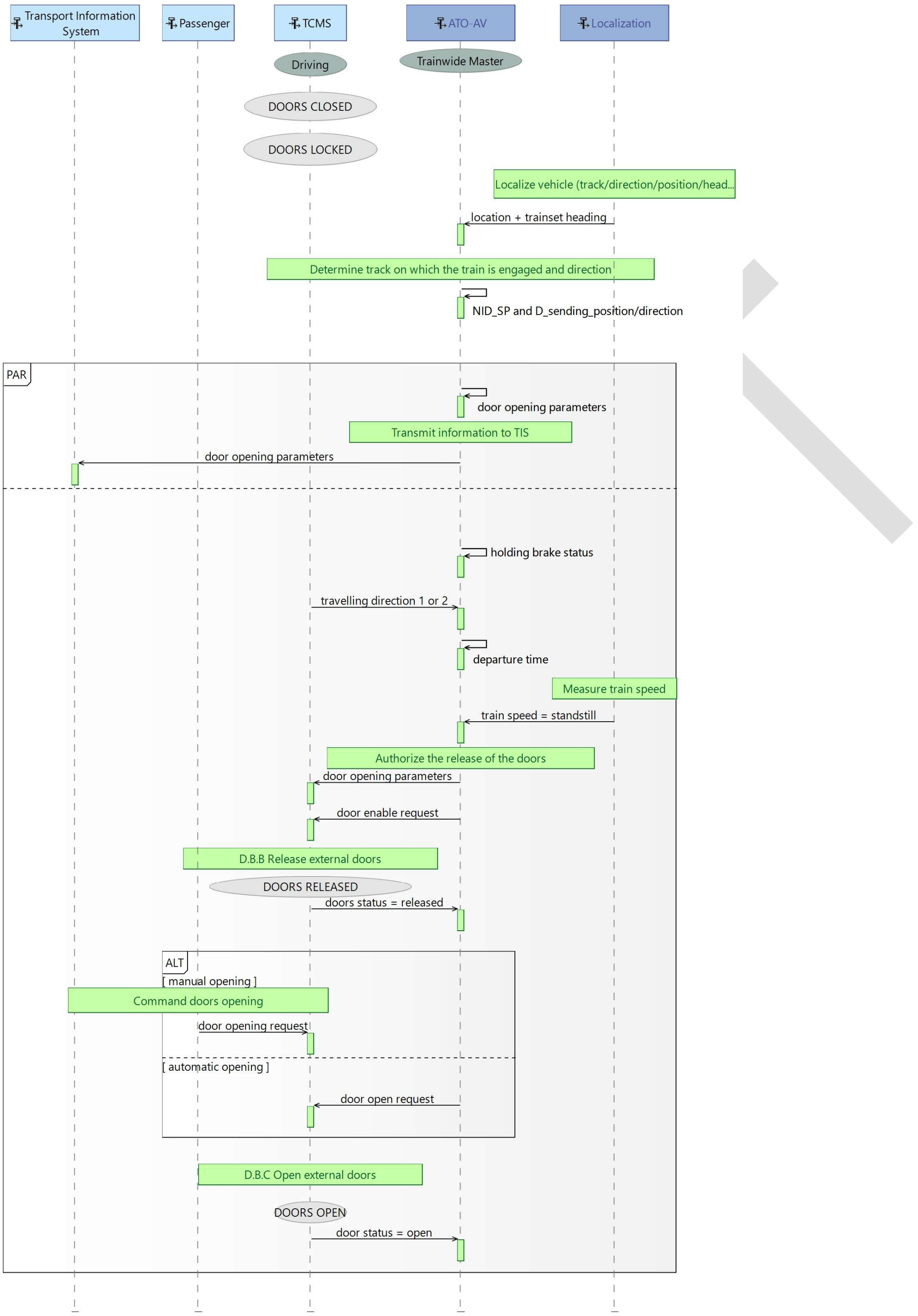
This Use Case describes the specific commands associated to the departure of a passenger train.




### 12.7.5 Door opening (passenger train)

This Use Case details the actions associated to door opening.

<u>Description</u>




### 12.7.6 Door closing (passenger train)

This Use Case details the actions associated to door closing.

Description

The minimum dwell time and the departure time are transmitted through the JP, they are defined in real time by TMS according the current situation.  It is possible to define a longer dwell time during peak hours for example.

The departure time is the reference time written on the passenger ticket, it does not exist in urban applications where the priority is given to the headway. It is not possible to close the doors earlier than foreseen in the JP (departure time minus train dependent door closing time) because it does not correspond to the service offered to passengers.

Operational rules are necessary to avoid a delay due to a late closing of the doors. For example, a TGV passenger ticket indicates that doors will be closed 2 min before the departure or 20s for an intermediate station. In the case where the doors are automatically closed for saving HVAC energy, it is assumed that a door can still be opened by passenger just before this time but after, the door closing process starts and door opening should be inhibited.

The regulation need must be managed by TMS because it has a more complete view of the traffic than ATO-AV. Even if an arrival time in station can be computed very precisely by ATO with the detailed knowledge of the train, it is TMS that has the best view of the run through several stations with the feedback of ATO and current traffic in the area.

A shorter dwell time can be transmitted to ATO-AV via a new JP. It is assumed that a dynamic management of the dwell time by TMS based on the predictions of ATO-AV and a correct refreshment rate of JP (required anyway to avoid ATO disengagement in case of route modification) can answer to the regulation needs.

A longer dwell time can also be transmitted to ATO-AV via a new JP (e.g. waiting a delayed connecting train).

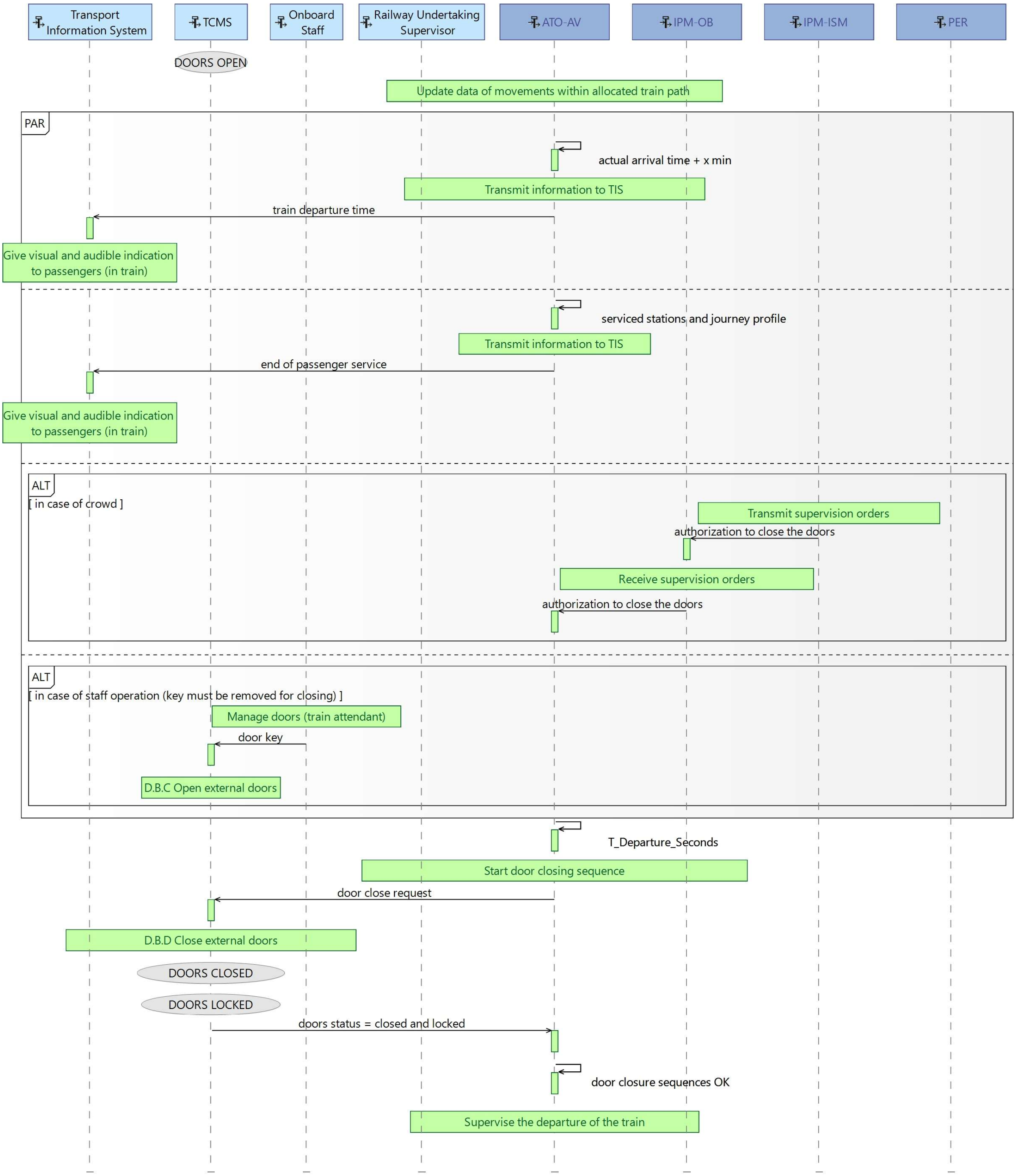
Door system manages the passenger flow and a partial re-opening of the doors in case of obstacle. An incident will be reported only if the system is not able to close the doors. For older trains, a retrofit is not expected and a train attendant should operate the doors in GoA3.

If a key is inserted in the door system by RU staff like today (cleaning, PRM support...), the closing process is delayed until the key is released (TCMS function).

Note:

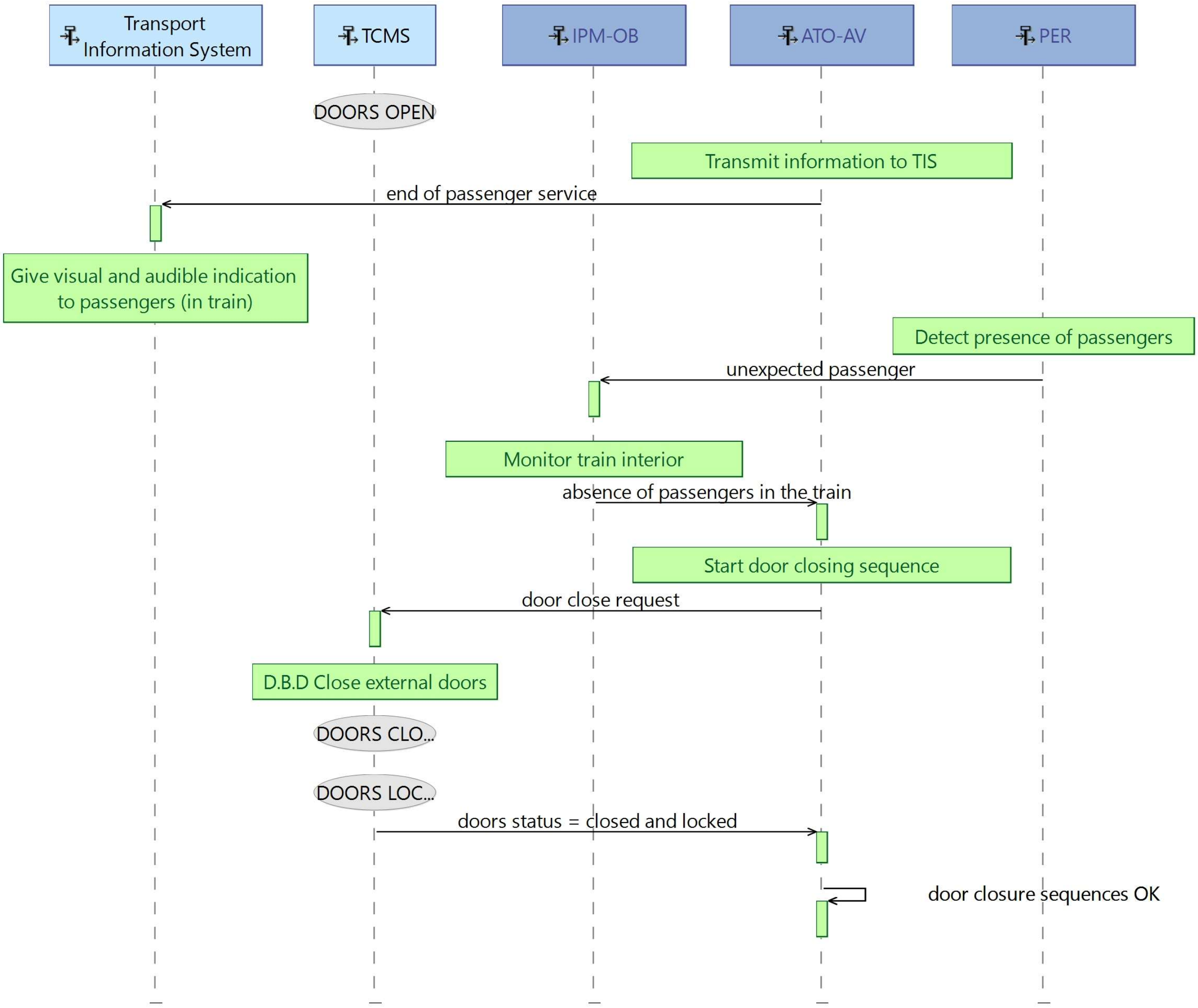
In mass transit, the forced door closing is usual in case of peak hour. After announcement, the passenger knows that the closing sequence will not be interrupted and that the doors will trap him in an uncomfortable manner. It avoids repeating a door closing sequence of 10s that would have a bad impact on headway. Nevertheless, TCMS will inhibit train departure if a door remains open to ensure safety.

On main lines, a new door closing sequence is possible in case an obstacle is detected. Several solutions are possible, IPM could decide to activate a new sequence after a configurable time for example. Door closing is under the responsibility of RU unless RU and IM are an integrated entity.




### 12.7.7 Door closing at the end of passenger service (passenger train)

This Use Case details the actions associated to door closing when service is finished.



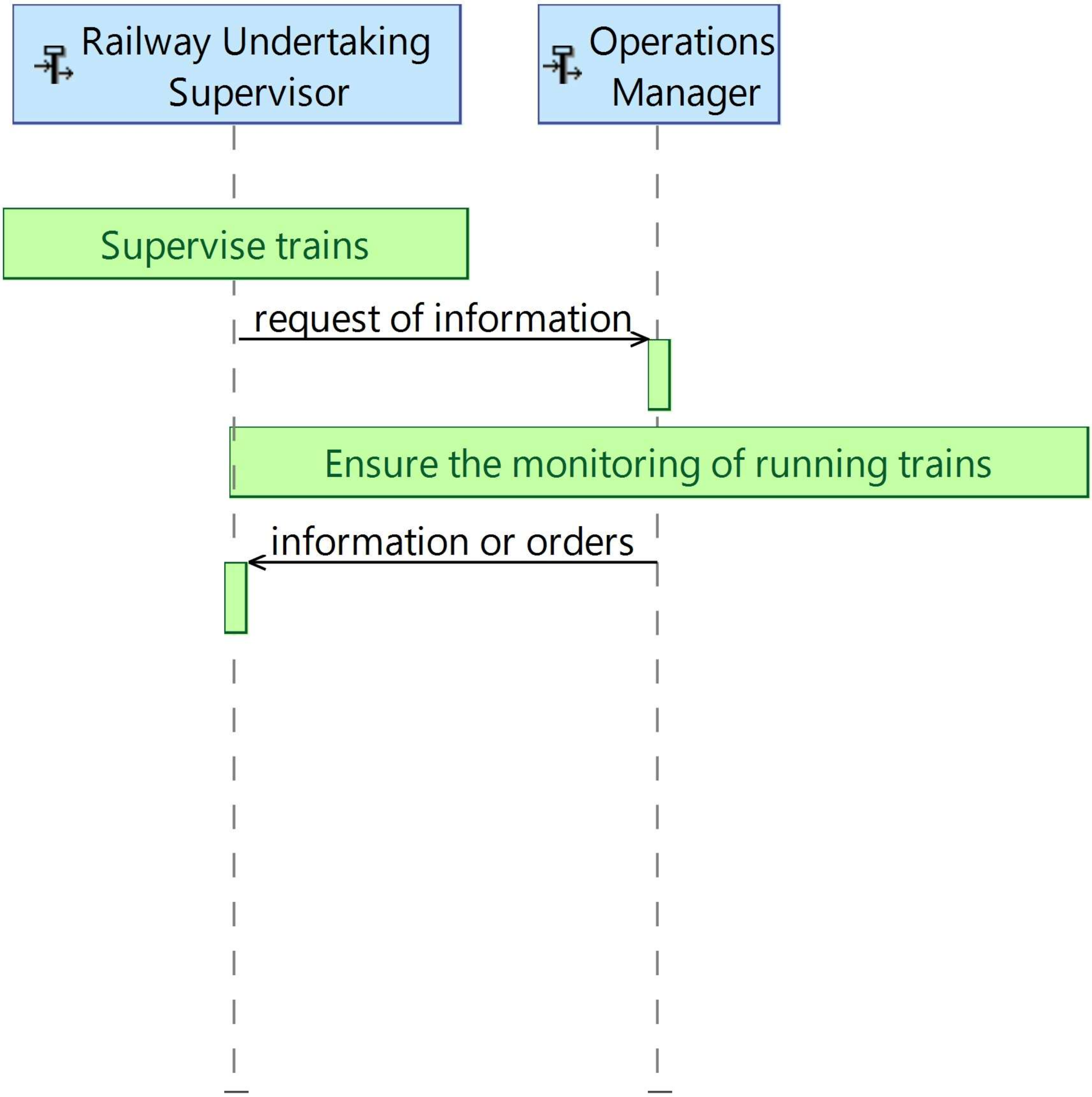

## 12.8 Non regular situation low level scenarios

### 12.8.1 RU IM verbal interface

This Use Case details exchanges between RU and IM during migration phase (existing TMS).

<u>Description</u>

During migration phase, RU Supervisor ensures some verbal communication with IM dispatcher, as a driver does today. This is a temporary solution before a full automated system.

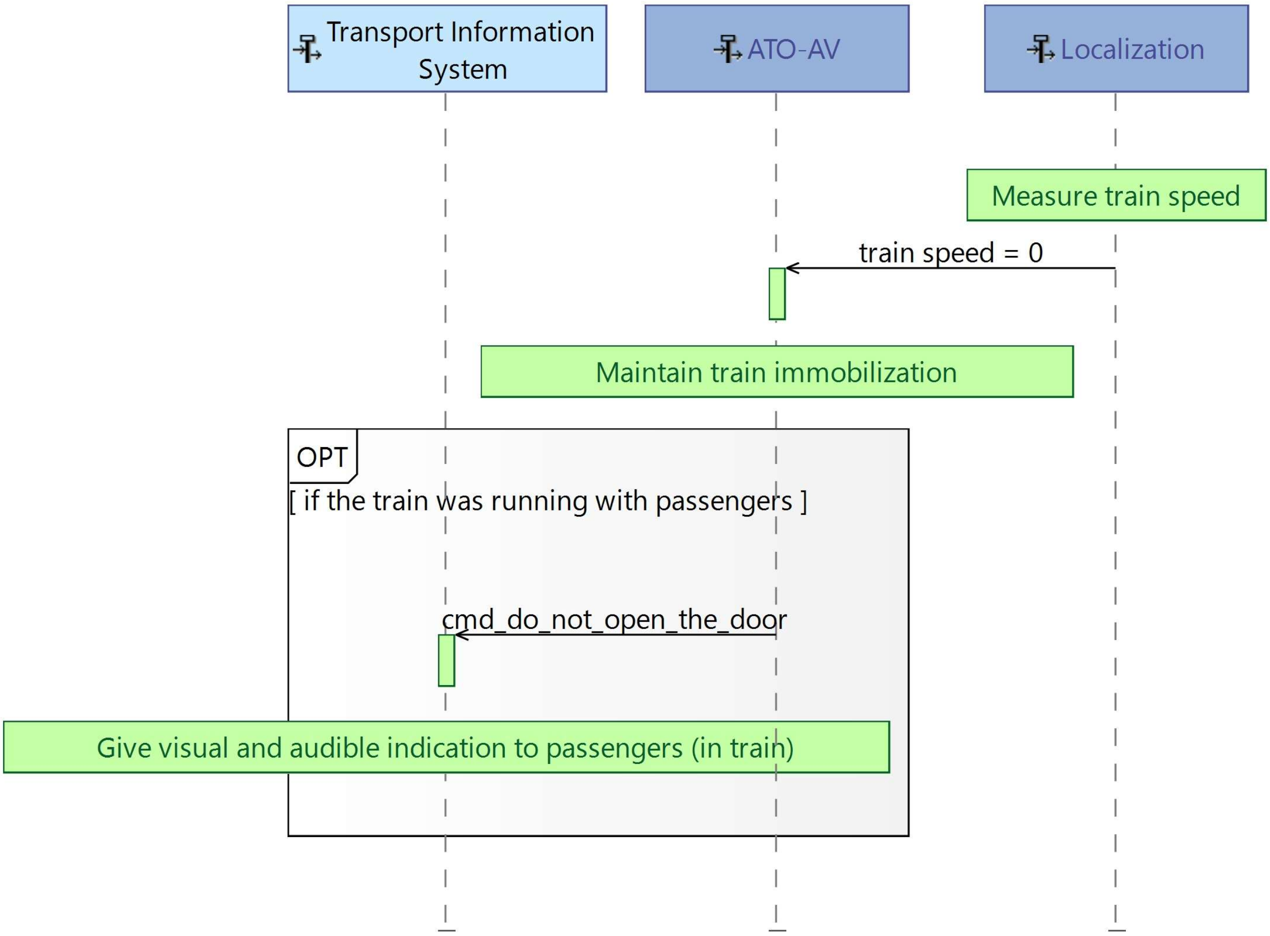



### 12.8.2 Unexpected stop

This Use Case details the actions to be taken in case of unexpected stop to inhibit door opening.

Description

This UC prevents passengers from leaving a stopped train in case of incident unless the train is in a station.

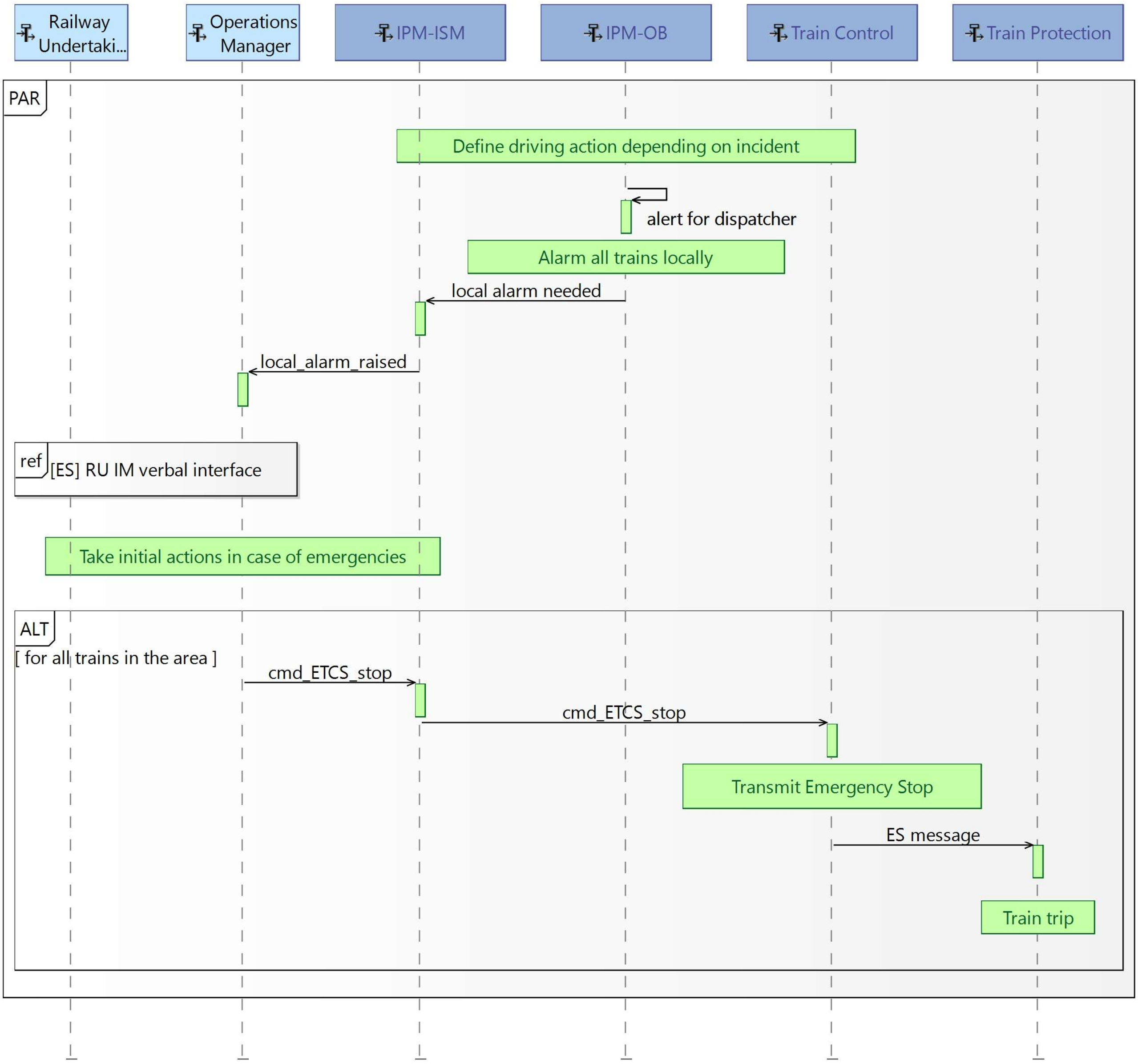



### 12.8.3 Set local alarm

This Use Case details the actions to be taken in case a local alarm is required.

<u>Description</u>

This UC permits to send an Emergency Stop message to all trains present in the vicinity of a train facing a major incident like derailment.

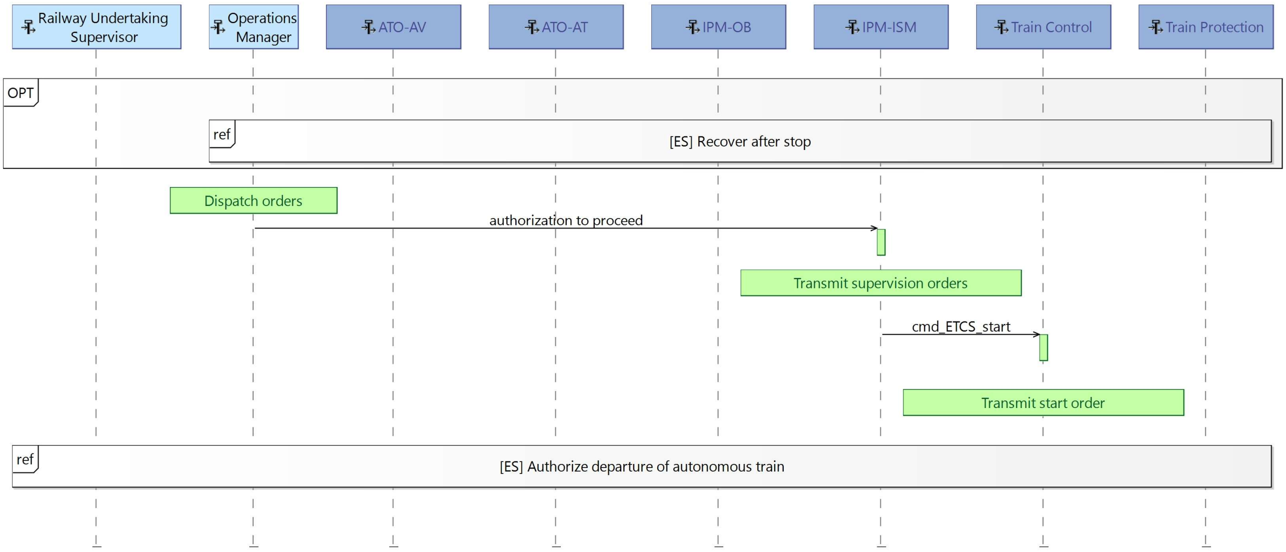



### 12.8.4 Restart after unexpected stop

This Use Case details the restart procedure after an unexpected stop.

<u>Description</u>

The written orders given to the driver in GoA2 could be transmitted directly to onboard ETCS via C31 interface with IPM trackside.



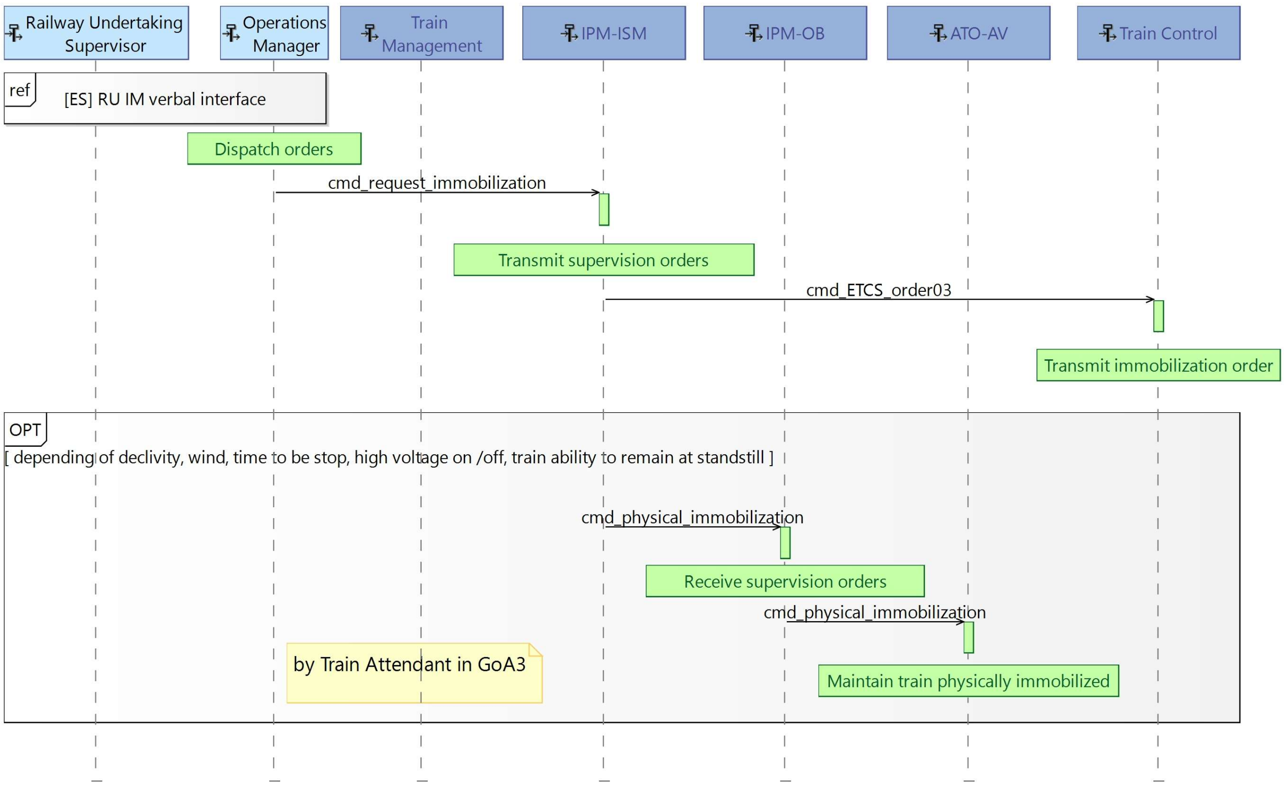

### 12.8.5 Request immobilization

This Use Case details the actions for immobilizing a train.

Description

The parking brake is not sufficient to guarantee the train immobilisation. In GoA2, the driver can put scotches to secure the train. In GoA3, it can be done by the train attendant. In GoA4, TCMS must provide an improved parking brake (spring-loaded brakes for example) to avoid a human intervention.

Note: this function is also required in ETCS L3 where the detection of cold movements is no more ensured by trackside detection devices.




### 12.8.6 Move the train locally

This Use Case details the local control of a train by trackside staff under the supervision of Emergency Manager.

Description

Emergency Manager from IM can order to a local emergency staff to take the control of the train for a local movement. The remote driver interface C13 can be used for that purpose to permit a handshake process with ATO-AV before to enter in remote driving (interface C48 with TCMS). The local remote control should be limited to small distances from a few meters (for checking if an axle is blocked after hot box alarm) to a distance equal to the train length (for clearing a point). The train speed must be limited to a pedestrian speed to permit a correct control of the staff. The use of the Perception system from GoA34 is not expected because the staff has a better visibility of the situation under the train and on the train sides.

It is assumed that ETCS, GoA34 and TCMS systems are healthy, the train is protected by ETCS. In case of failure of GoA34, the handshake process with GoA34 is no more possible to take over the control but TCMS remote control mode can be forced by RU (see remote driving topic).

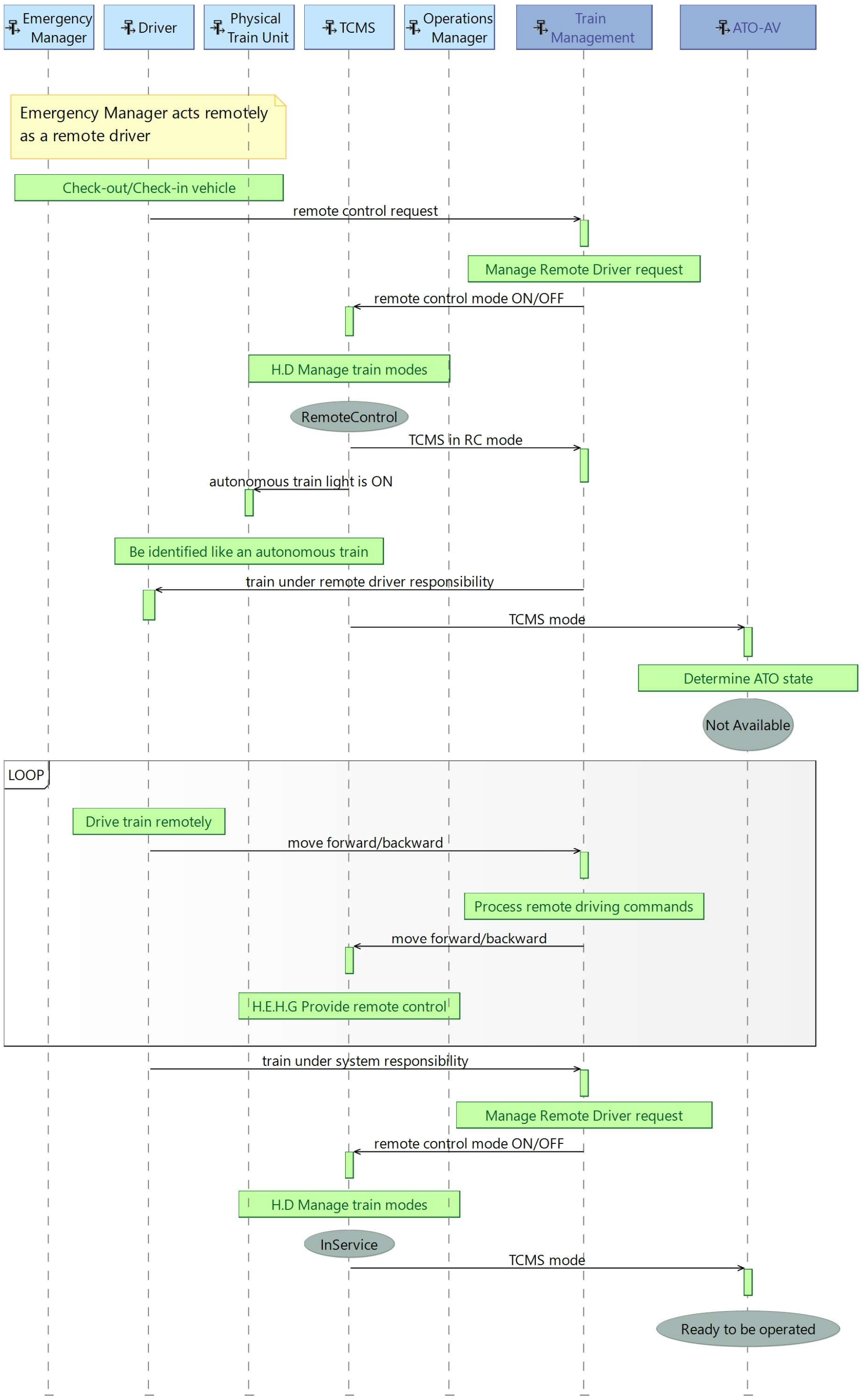
For small movements (one wheel rotation to check an axle for example), SR distance does not seem appropriated. A simple solution could be a direct interface between local staff and TCMS (interface C7 with RFID for example) to allow a short movement or 2 or 3m under the responsibility of the local staff (eventually repeated two or three times). Interface C48 could be used for the same purpose to ensure interoperability.

For longer movements (about a train length), the local staff has access to the traction and braking commands (SS-139) when TCMS is in remote control mode. The remote control speed is supervised by TCMS (pedestrian speed of 5 km/h) but this train related speed restriction should also be controlled by ETCS via SS-034. IPM could be used with Train Control to issue a SR authorisation with speed limit and a maximum distance (train length for example). The movement could be forwards or backwards.

The communication channel for remote control must be safe. Cybersecurity and delays must be considered. A loss of communication must lead to brake application. Remote driving implies a robust communication system (coverage levels are specified in UIC 951 with a coverage probability of 95 %).

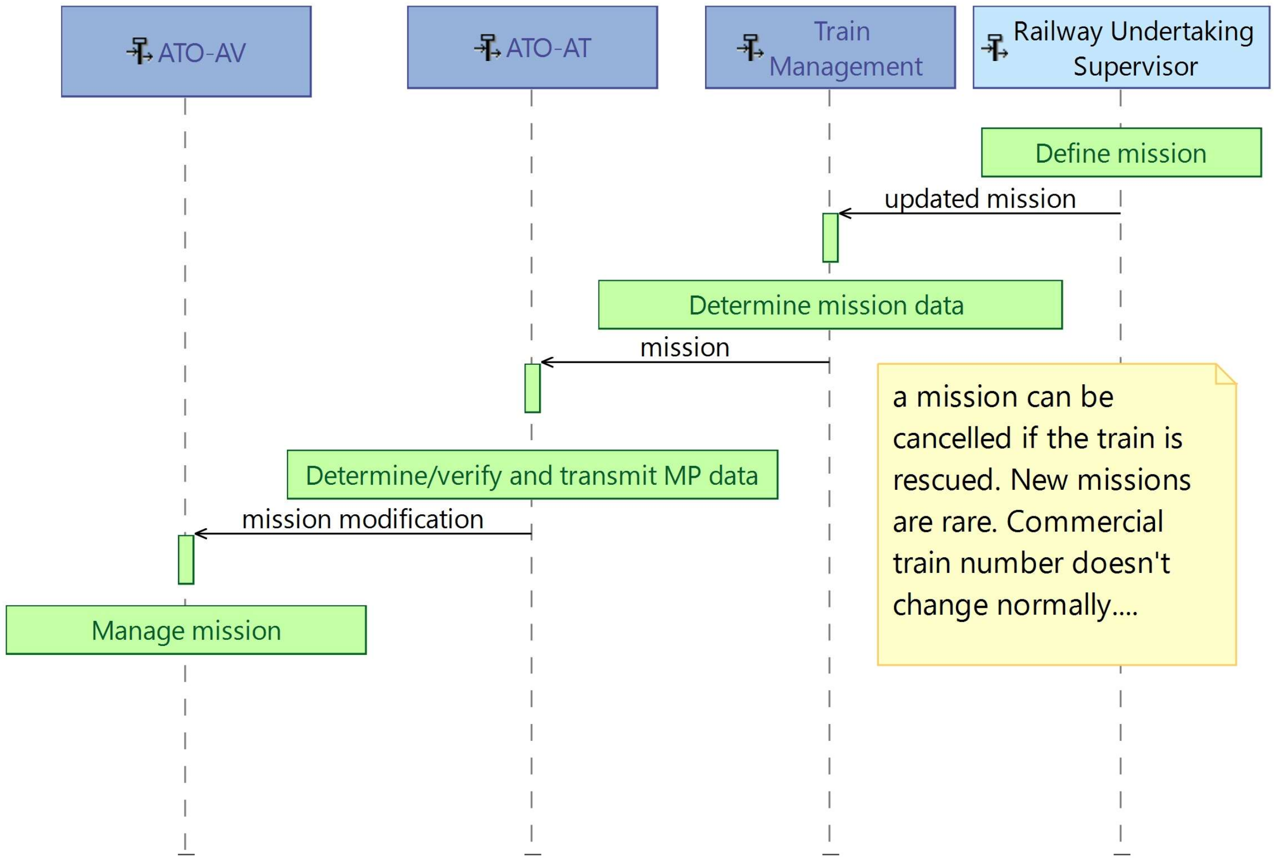
A specific lamp is required on the train to inform that train is under control (autonomous mode or remote control).

ATO-AV remains operational. In the existing STM, the nominal mission of GoA34 is interrupted by a request for taking control. GoA34 system enters in Standby mode and a key from local staff should permit to go to Ready to be operated mode before to enter in Not Available mode (local staff is considered like a remote driver). In this mode, ATO does not activate traction or braking to TCMS. An alternative is to create a specific GoA34 mode for such movement.



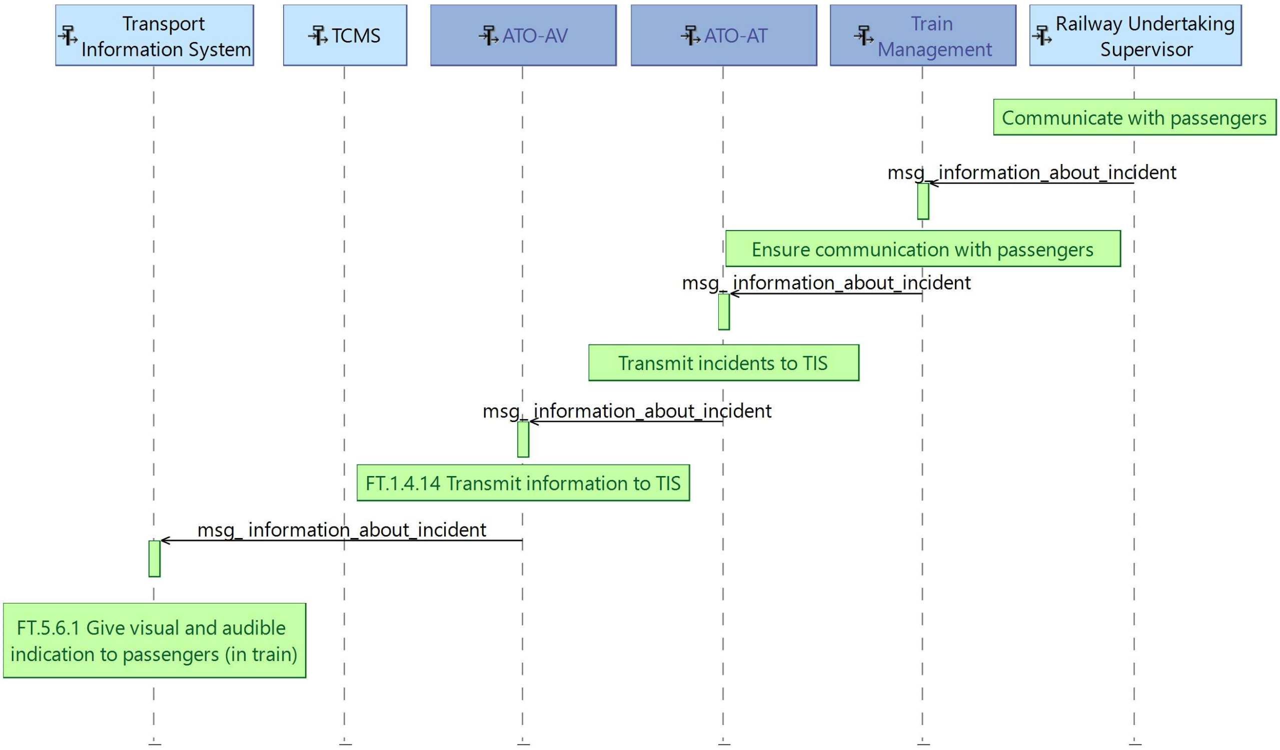

### 12.8.7 Update Mission

This Use Case details the actions to be taken for a change of mission in very specific situations.




### 12.8.8 Inform continuously passengers

This Use Case details the communication of incidents to Passengers.




### 12.8.9 Track or train observation

This Use Case details the actions to be taken in case a damage is identified on the train or on the track.

Description

If a subsystem failure presents a risk for passengers or freight, it must be reported to IPM (the failure of a fire detection system will forbid access in a tunnel for example). For all other cases, RU is the only entity to be informed through Train management (lavatory problem for example). Another example is a climate failure in a coach which is not critical but a complete HVAC failure must be reported.

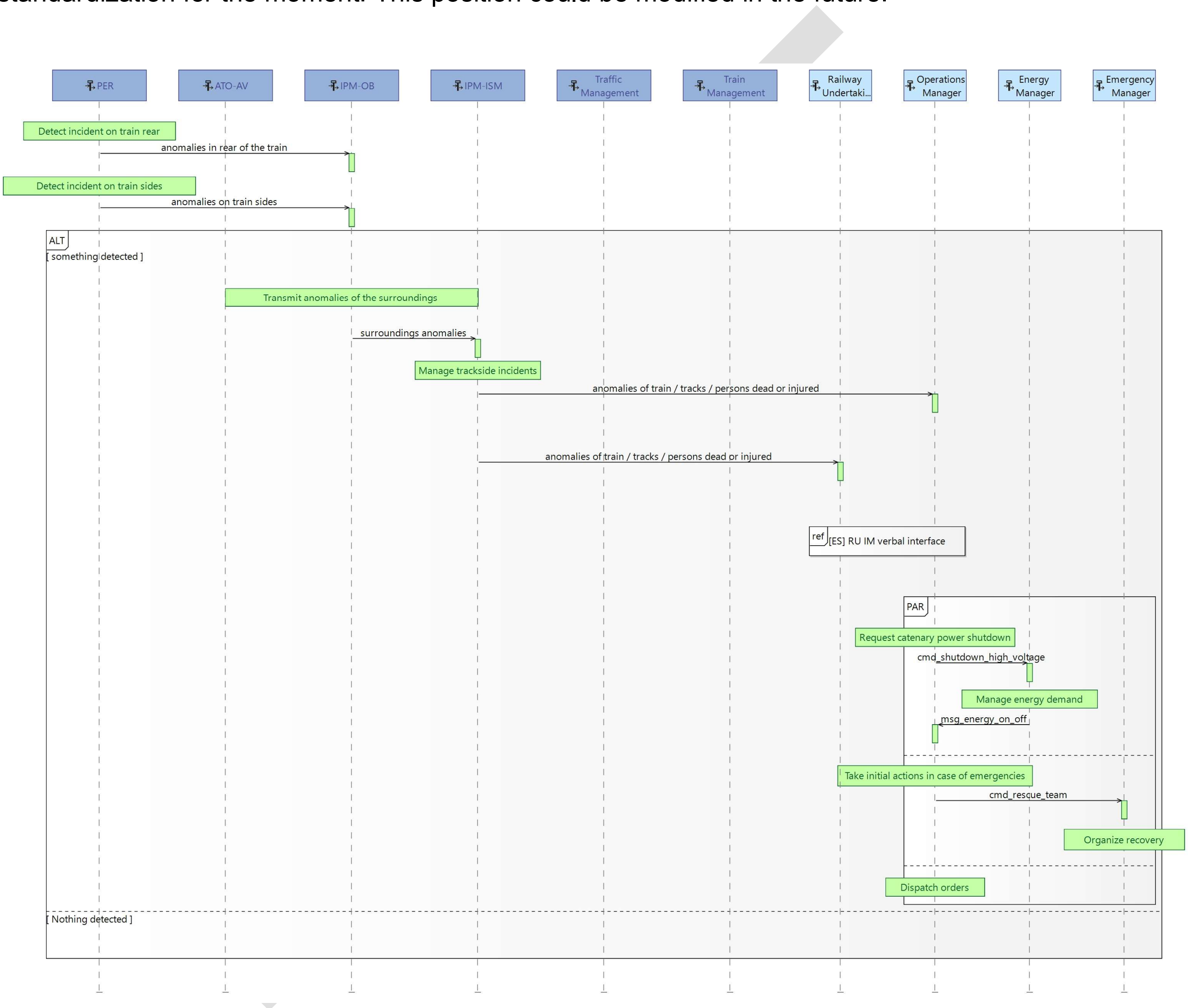
In GoA2, the driver can manage the degraded situations, even an unlikely event like a runaway consecutive to a collision with an obstacle. A reporting through IPM in GoA34 should permit to achieve the same result i.e. diverting the train in the example. A future system should perform even better (modern Rolling Stock, new ETCS and GoA34 functions...).

The failure of the perception system must be analysed, it is closely related to the various sensors mounted on the train. Degraded perception could impose a speed restriction for example.

The use of PER to detect incidents on the crossing trains (especially the freight trains) is seen as an important advantage. It should avoid exported constraints like the installation of trackside detectors.

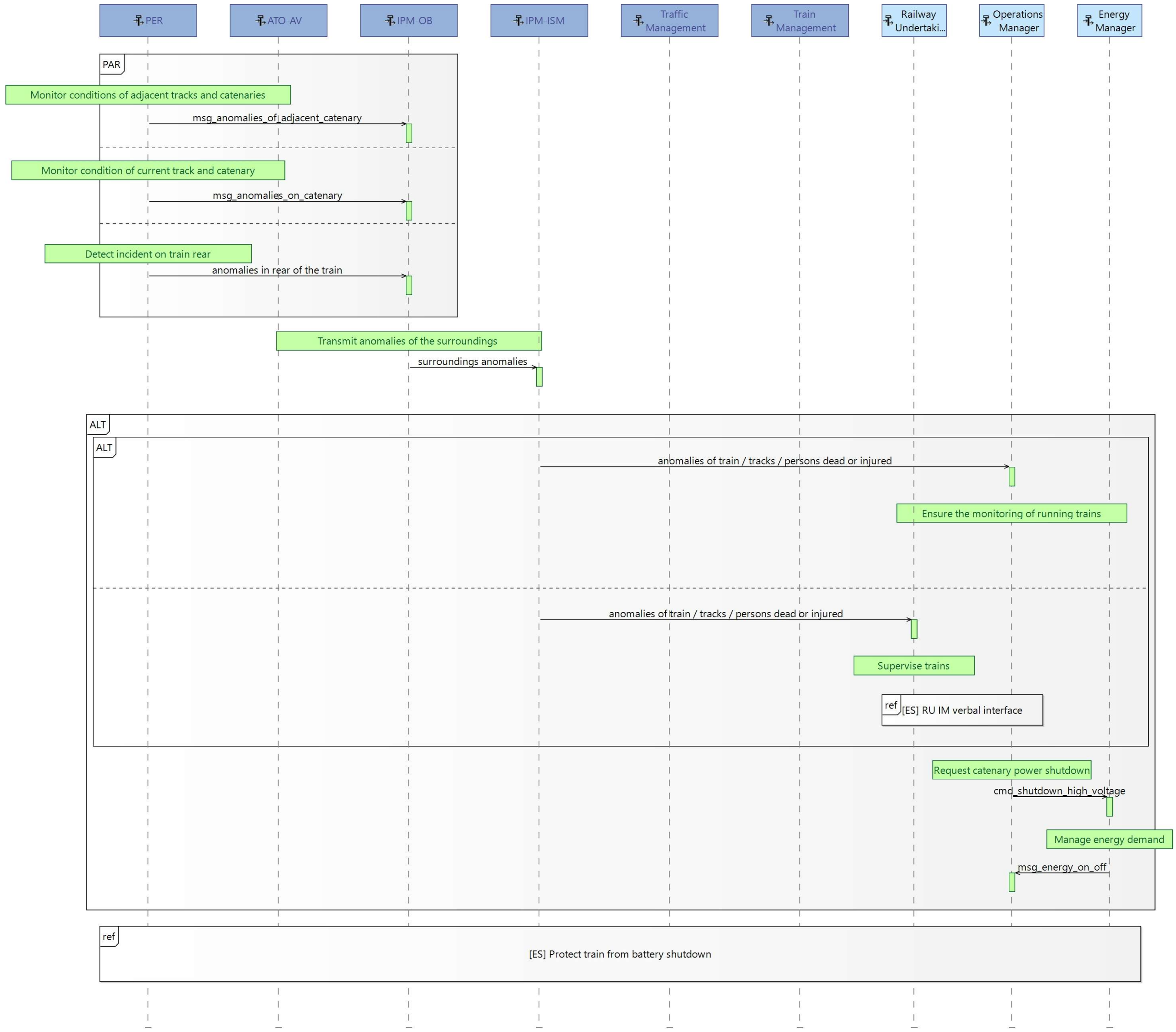
Feedback from Connecta and RS suppliers is very important to define a GoA4 solution that is not too expensive in comparison with GoA3. The interface with TCMS must be defined carefully because it has a direct impact on homologation of GoA34.

Note: Connecta focuses on normal application interfaces and leave the diagnostics out of the standardization for the moment. This position could be modified in the future.



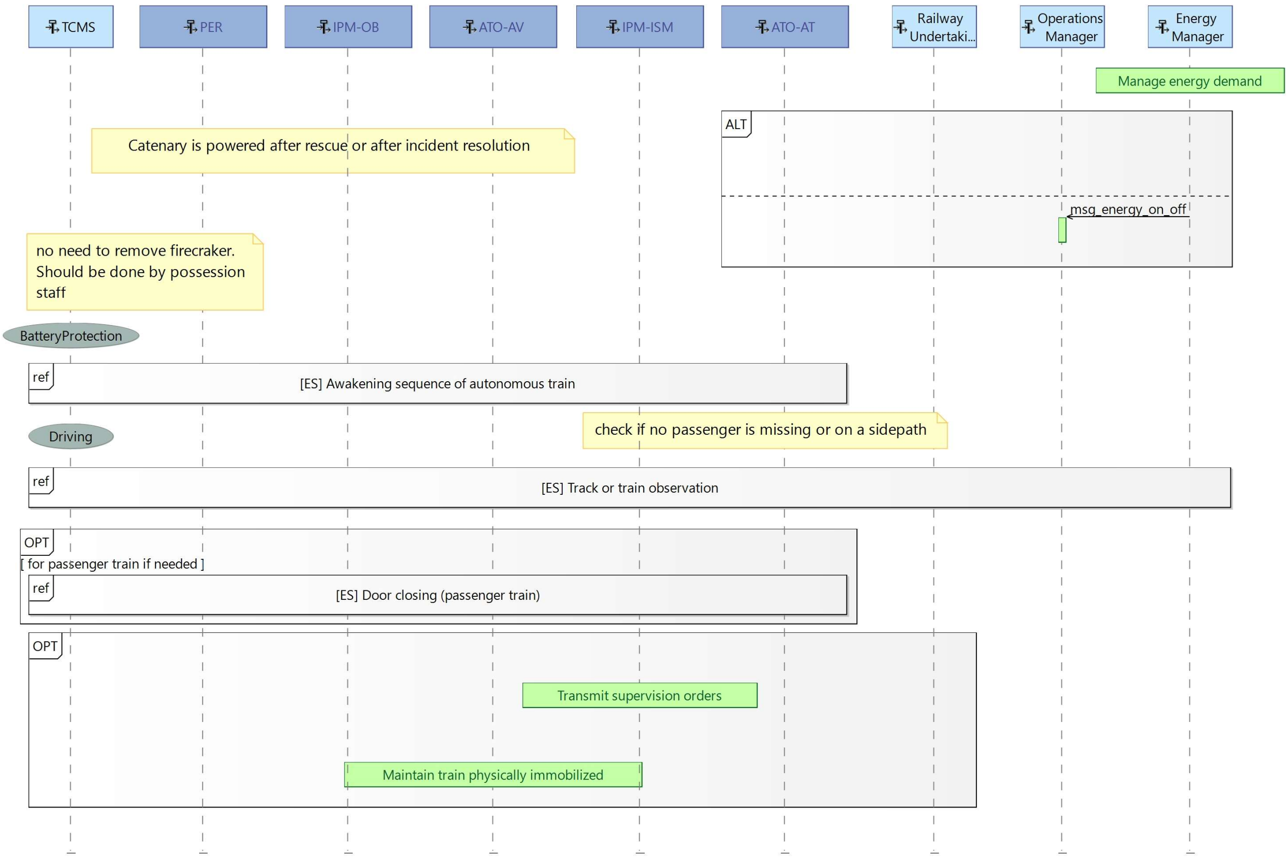

## 12.8.10 Ask catenary power shutdown

This Use Case details the procedure to shutdown the catenary power in case of emergency.



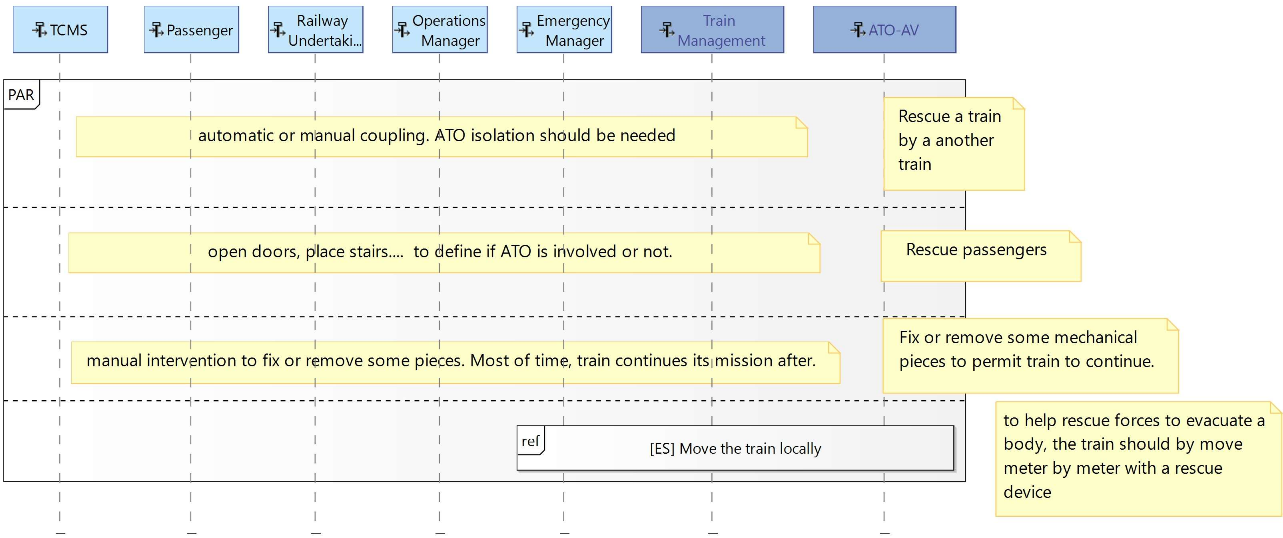

### 12.8.11 Recover after stop

This Use Case details the recovery procedure.




## 12.8.12 Organize Rescue

This Use Case details the rescue procedure.




## 12.8.13 Stop at next station or rescue point

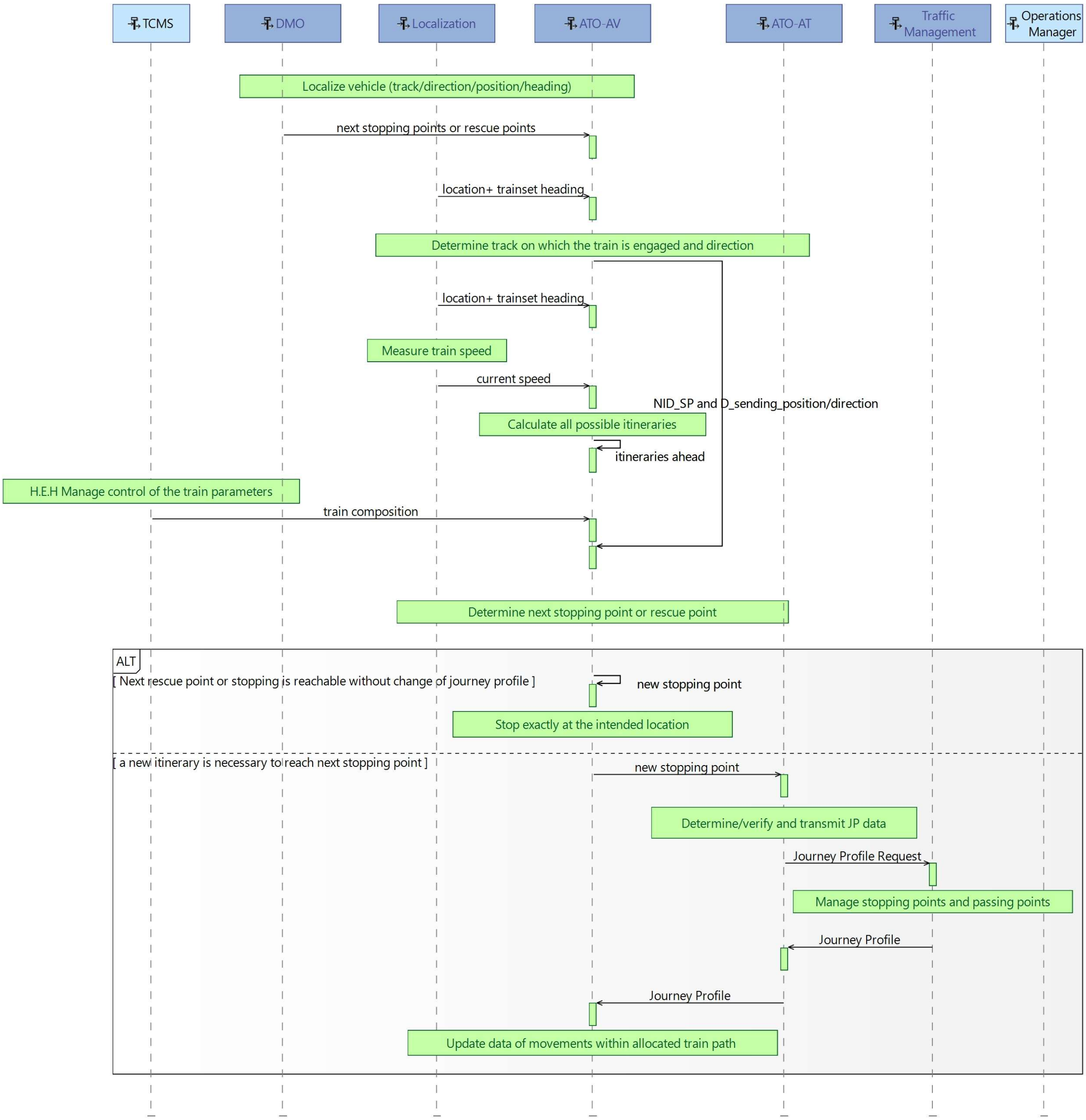
This Use Case details the stop procedure.

Description

When a trouble appears, IPM-OB may command a brake to next station or next safe stopping point or order a TSR. ATO-AV has thus to modify the current JP accordingly. In a second time, IPM trackside could confirm or invalidate the foreseen action and TMS will calculate a modified JP or order another one.

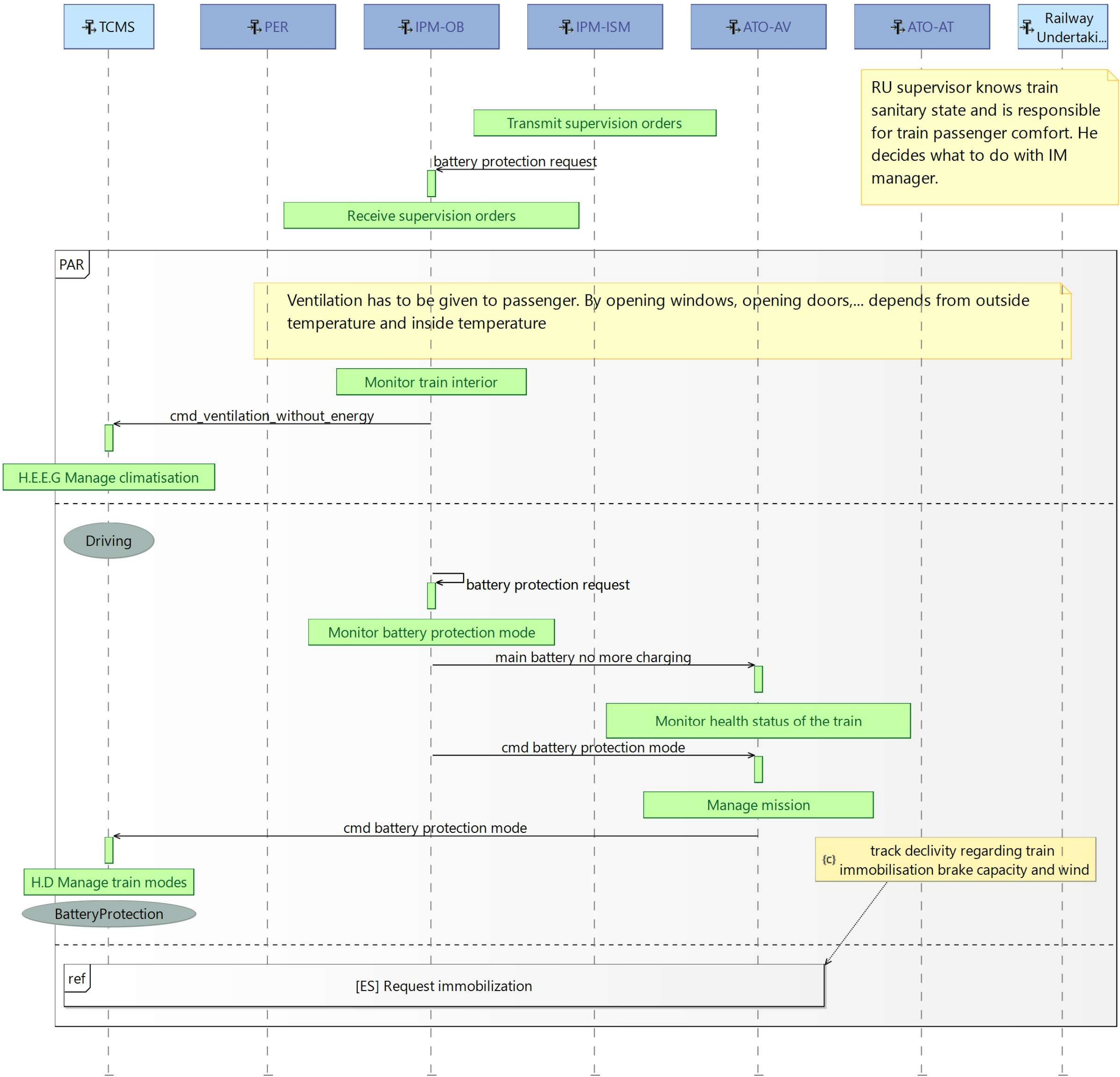
This is a subsidiary function of TMS on board: for immediate reaction, to deal with a loss of communication or for ATO working without TMS.

Example: in case of fire, a train is allowed to run 15 minutes i.e. a longer distance than current MA i.e. ATO-AV can calculate an operational stopping point beyond MA.




### 12.8.14 Protect train from battery shutdown

This Use Case details the actions for setting TCMS in Battery Protection mode.

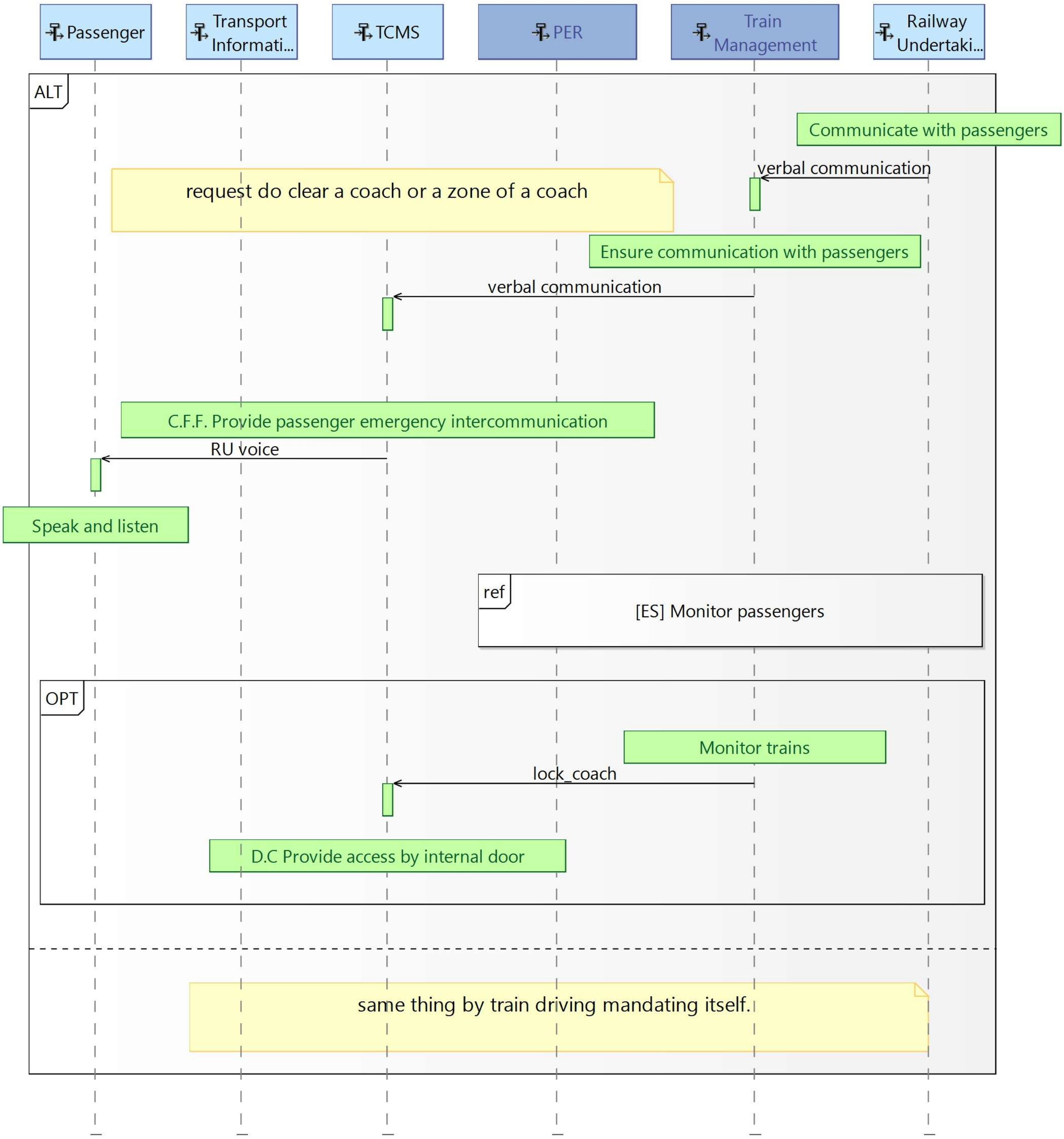



## 12.8.15 Move passenger to safer zone

This Use Case details the actions necessary to clear a coach or a zone of a coach before to lock it.

Description

The passengers will be requested to move to a safer zone in case of incident like a broken window, insufficient light or hvac failure for example.




### 12.8.16 Monitor passengers

This Use Case details the CCTV monitoring of the coaches by RU on request.

Description

General Data Protection Regulation (GDPR) must be considered when using the images, RU is the interface with passengers.

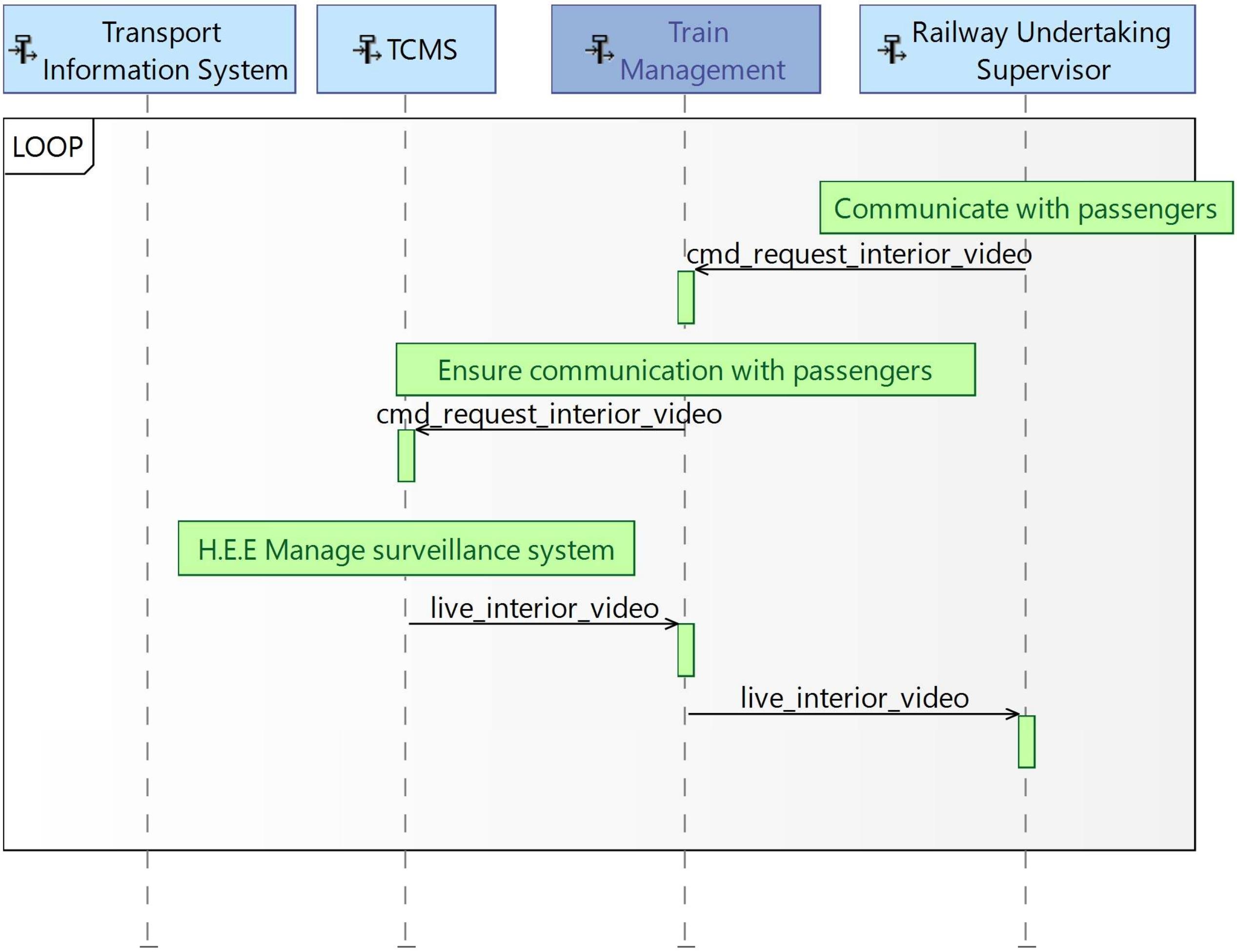
Monitoring of a night train is not expected because there is a train attendant for passengers in this case (GoA3).

A specific need is to check overcrowding. Overcrowding can be legal (operation to be adapted) or illegal (a tunnel access is forbidden when there are too many passengers in a coach for example).

IPM-OB will decide if overcrowding is legal or not. It must hold the train in case of illegal overcrowding until Train Management has solved the problem. Information transmitted to passengers can indicate free seats in another coach for example. A train speed restriction can also be imposed for passenger comfort with an impact on journey time.

If overcrowding is legal, IPM-OB must inform trackside of a possible impact on dwell time. ATO will supervise the adapted dwell times of the Journey Profile.

Counting of passengers could be performed via PER or via TCMS through weight measurement (it is assumed that weight information is used by TCMS for adapting the suspension). Current CCTV characteristics are probably not adapted for the counting of passengers. Resolution and coverage should be adapted for this new need if necessary.



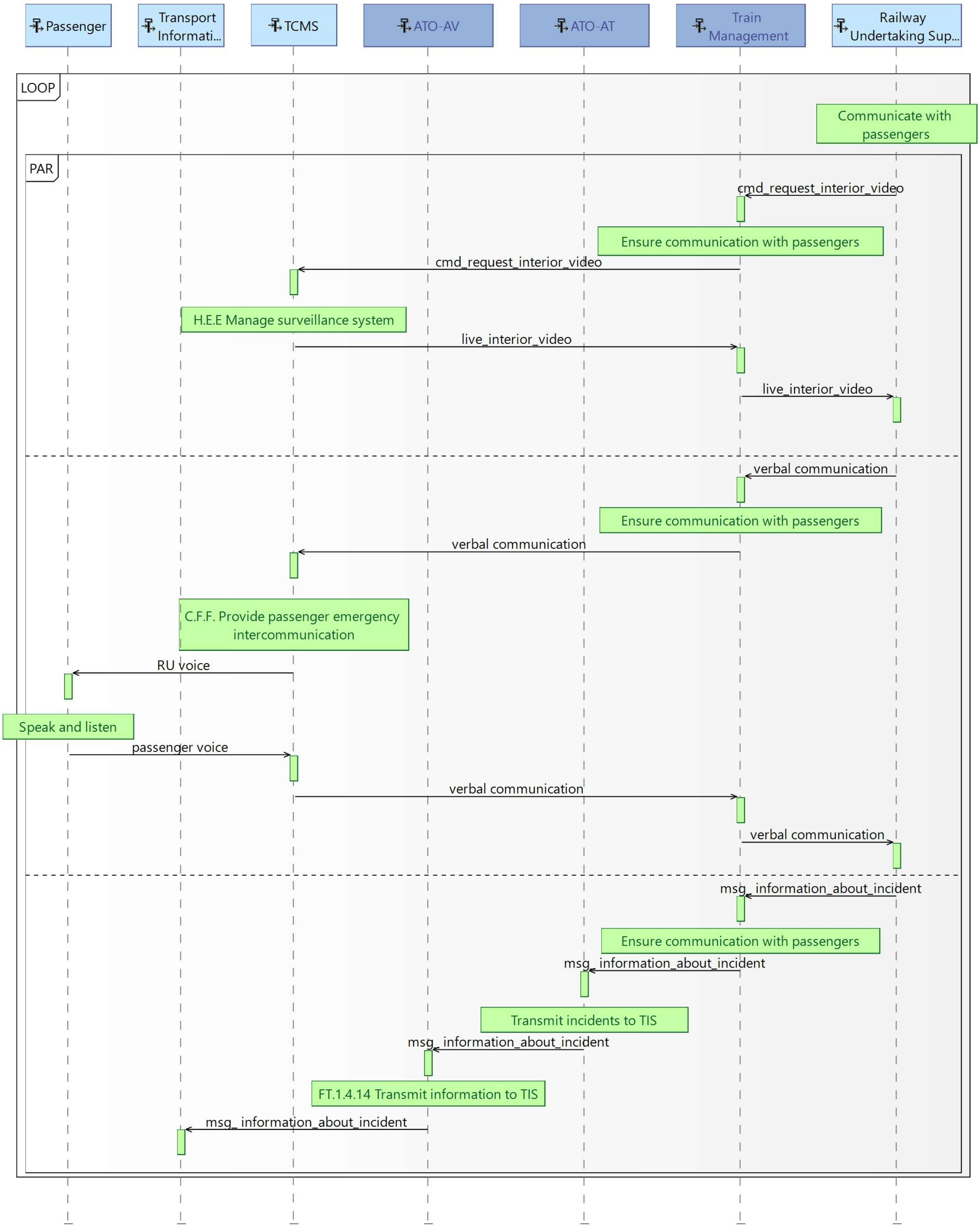

### 12.8.17 Establish communication with passenger

This Use Case details the communication with passengers by RU on request.

Description

RU has a direct link with TCMS to monitor train interior and communicate by voice with passengers.

A direct link between RU and TIS could be used to inform passengers about incidents but it could be standardised by the use of ATO channel like described in this use case.



Passenger
Transport Informati...
TCMS
ATO-AV
ATO-AT
Train Management
Railway Undertaking Sup...
LOOP
Communicate with passengers
PAR
cmd_request_interior_video
Ensure communication with passengers
cmd_request_interior_video
H.E.E Manage surveillance system
live_interior_video
live_interior_video
verbal communication
Ensure communication with passengers
verbal communication
C.F.F. Provide passenger emergency intercommunication
RU voice
Speak and listen
passenger voice
verbal communication
verbal communication
msg_ information_about_incident
Ensure communication with passengers
msg_ information_about_incident
Transmit incidents to TIS
msg_ information_about_incident
FT.1.4.14 Transmit information to TIS
msg_ information_about_incident

## 12.9 React to operation related incidents

### 12.9.1 React after misrouting

This Use Case details the actions to be taken in case of misrouting.

Description

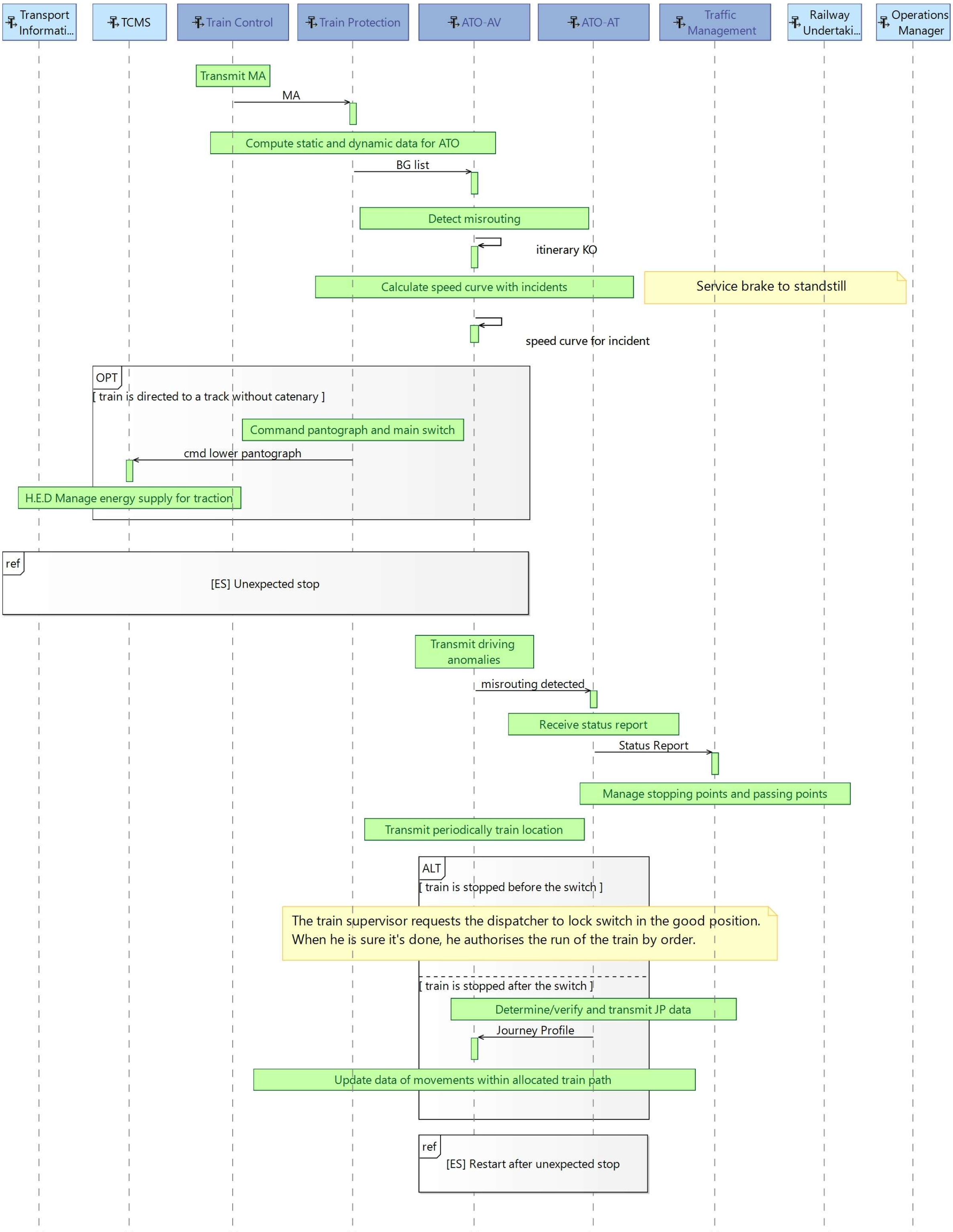
Itineraries are defined in the JP. A change of itinerary at TMS level is followed by a new JP but two different cases must be considered:

- change is normal, the train is routed to another platform for example

- in case of routing error, the JP could contradict the planned mission.

On lines equipped with ETCS, the JP must be refreshed in time to avoid that the list of balises transmitted with MA gives a conflict (ATO is disengaged).

Note: An option could be to transmit several JPs in order that ATO continues to run without being disengaged (not implemented in GoA2). ATO could recalculate the itineraries on board to fix a lack of communication or to verify if a situation of misrouting is really appearing or not (see «Calculate all possible itineraries»).




## 12.9.2 React on obstacle

This Use Case details the actions to be taken in case of obstacle detection.

Description

When an obstacle is detected, IPM sends an obstacle-MA or an unconditional ES to ETCS via C16 and informs IPM trackside (delay in operation). When the train is stopped, the feedback loop with the trackside permits to identify the problem and to restart when the problem is solved (false alarm for example).

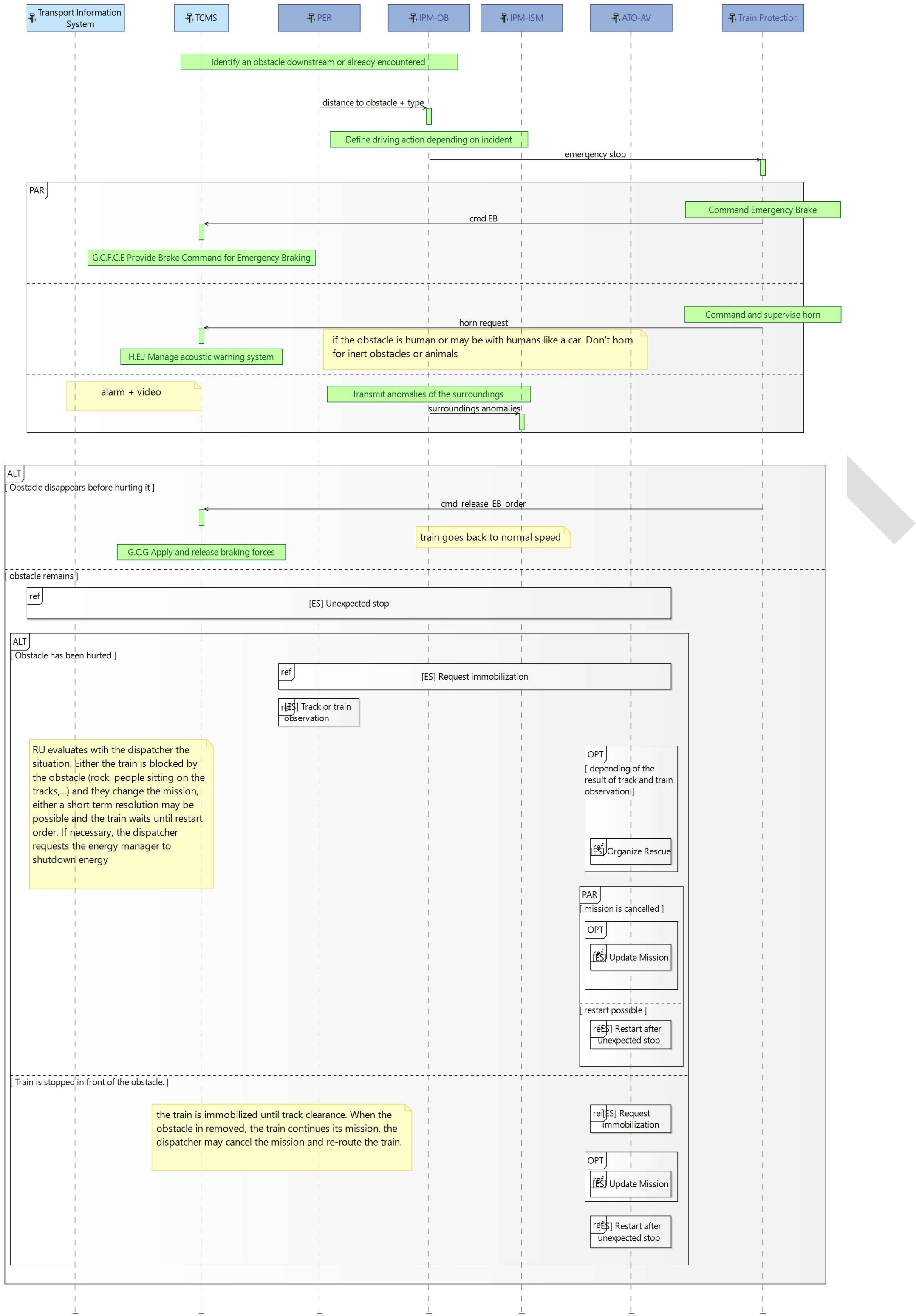
In case of obstacle-MA, if the train is stopped without trip, onboard ETCS will request a new MA to Train Control when the obstacle-MA is removed by IPM-OB. This removal could be done automatically if the obstacle has disappeared or via a confirmation of IPM trackside through C19 interface if there is a doubt. If the obstacle is still present, the track must be closed until recovery. The case of an obstacle that has disappeared from Perception but is still present under the train must be considered.

In case of trip, IPM is safety related and can be used to acknowledge the transition to Post Trip mode. This authorisation should be given through C19 interface. Once in PT mode, onboard ETCS will request a new MA.

In case of unconditional ES, a revocation message is necessary before the sending of a new MA by Train Control. This message could be activated through IPM trackside and its C31 interface.

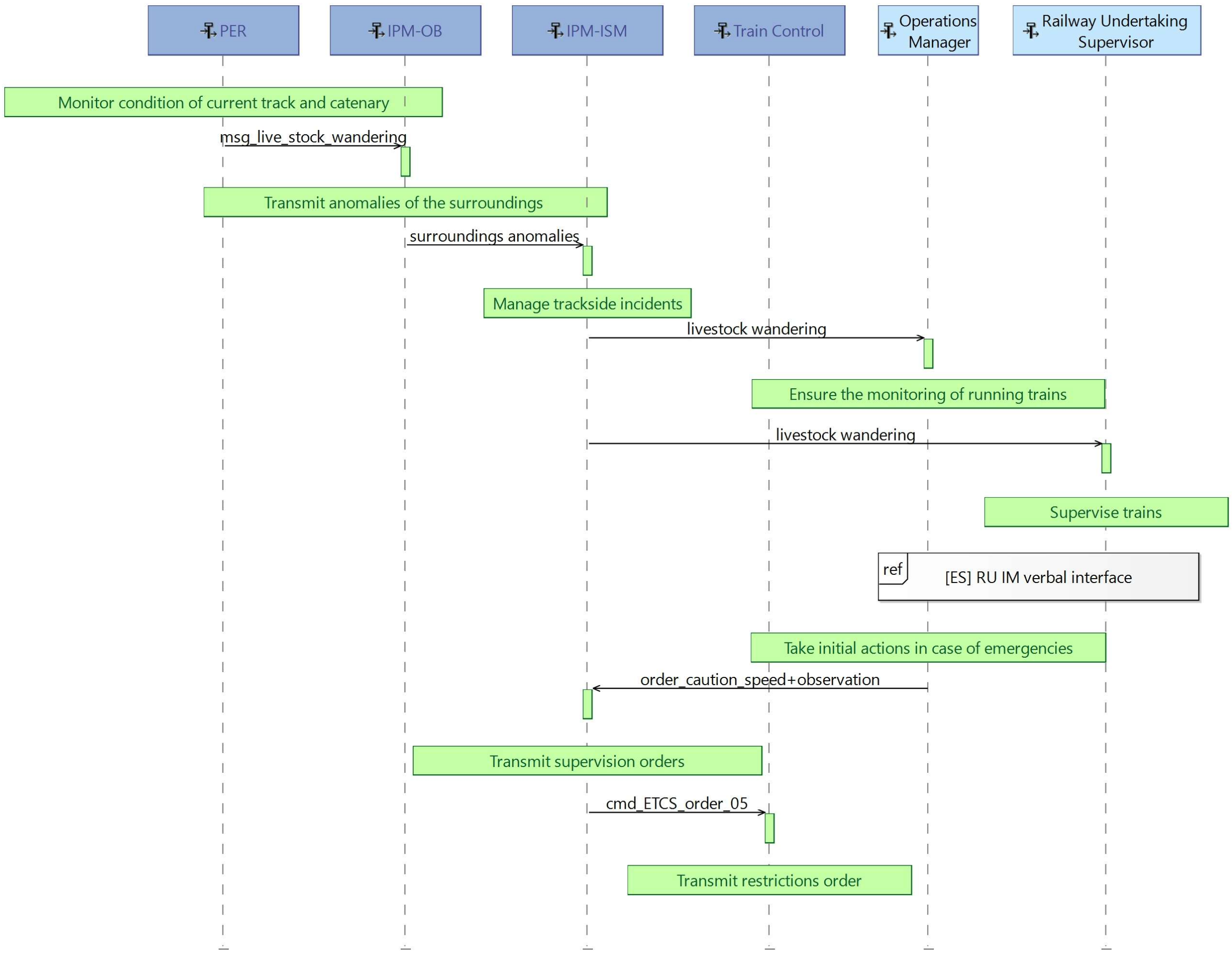
The level crossing is a specific case. In France and Germany for example, it is assumed that the level crossing will be protected in time (20 to 30s) and thus, a driver (or Perception) is not supposed to brake while observing cars crossing a level crossing before the barriers are closed. In comparison, the level crossing barriers related to a station are closed before the train departure. Depending on country and location, a level crossing can be completed with a monitoring system that will warn in case a car is blocked on the track (while track detection provides clear information). PER can be used for the same purpose when there is no such trackside monitoring system.

The use of remaining time or remaining distance before hitting the obstacle is an analysis to be performed at ETCS level. Today, ETCS has a feature to evaluate if it can brake within a given distance or not.



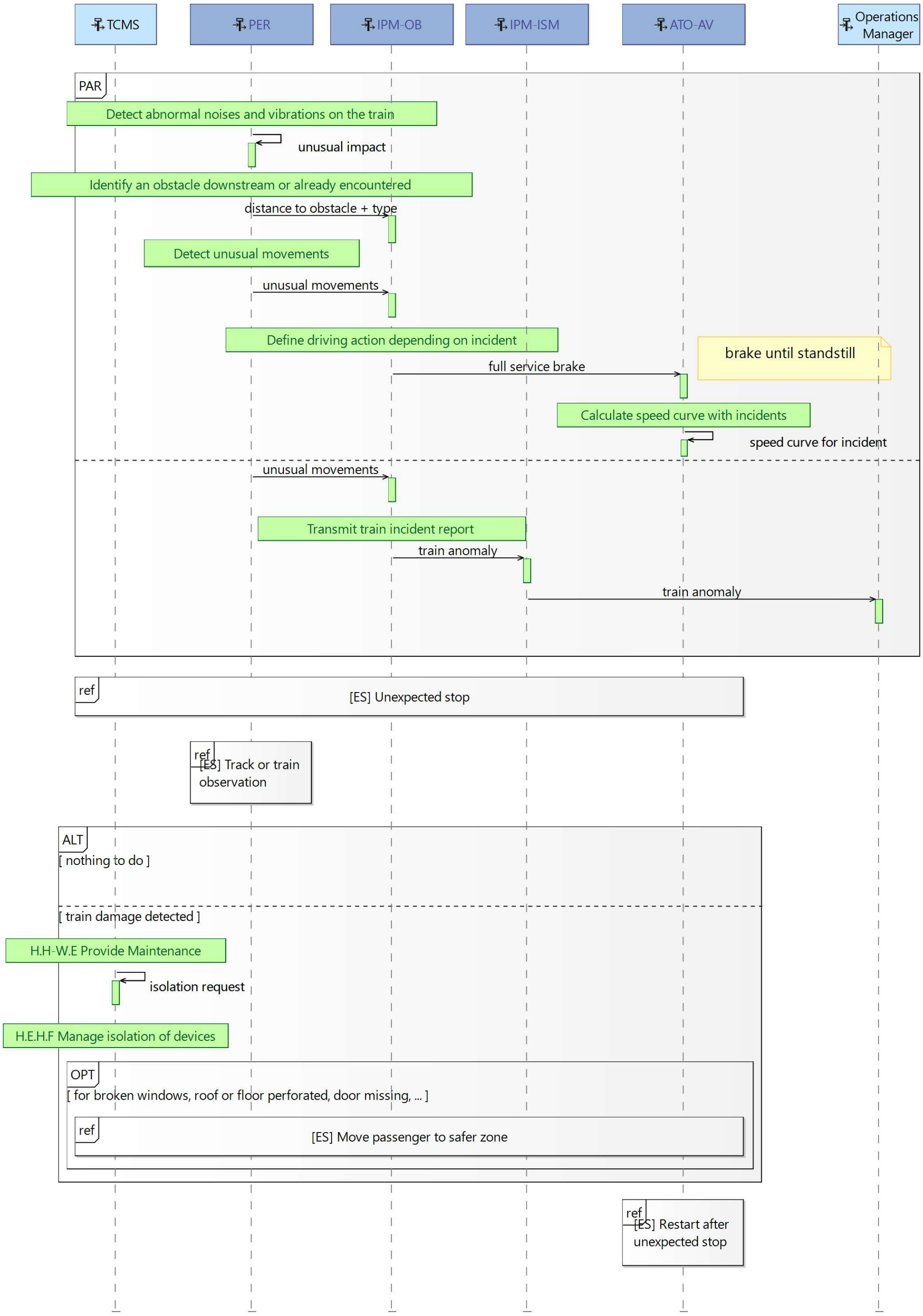

### 12.9.3 Wandering of livestock

This Use Case details the actions to be taken in case of livestock detection.




### 12.9.4 Unusual impact or movement

This Use Case details the actions to be taken in case of impact detection.

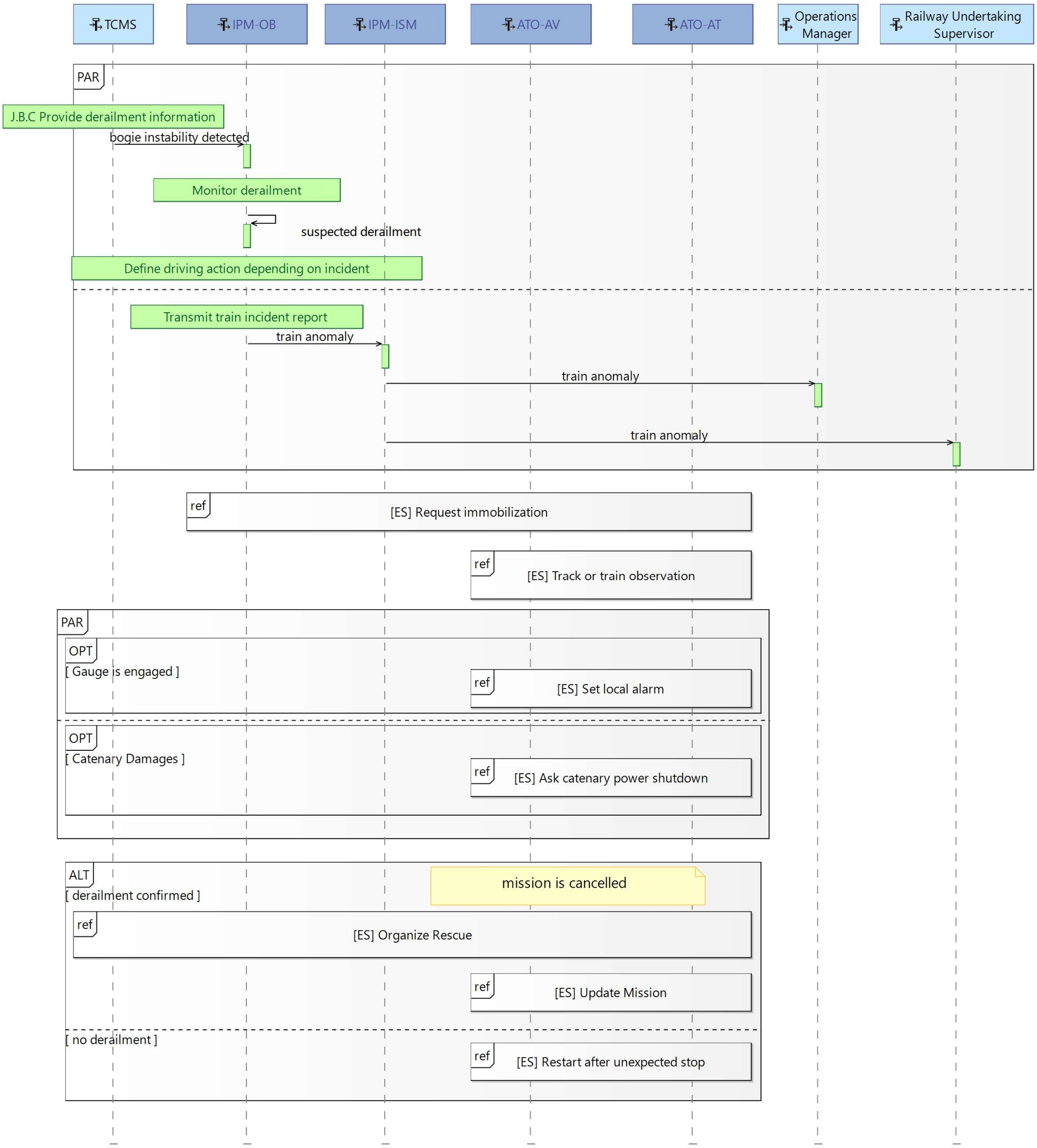



## 12.9.5 Derailment or presumption of derailment

This Use Case details the actions to be taken in case of derailment detection.

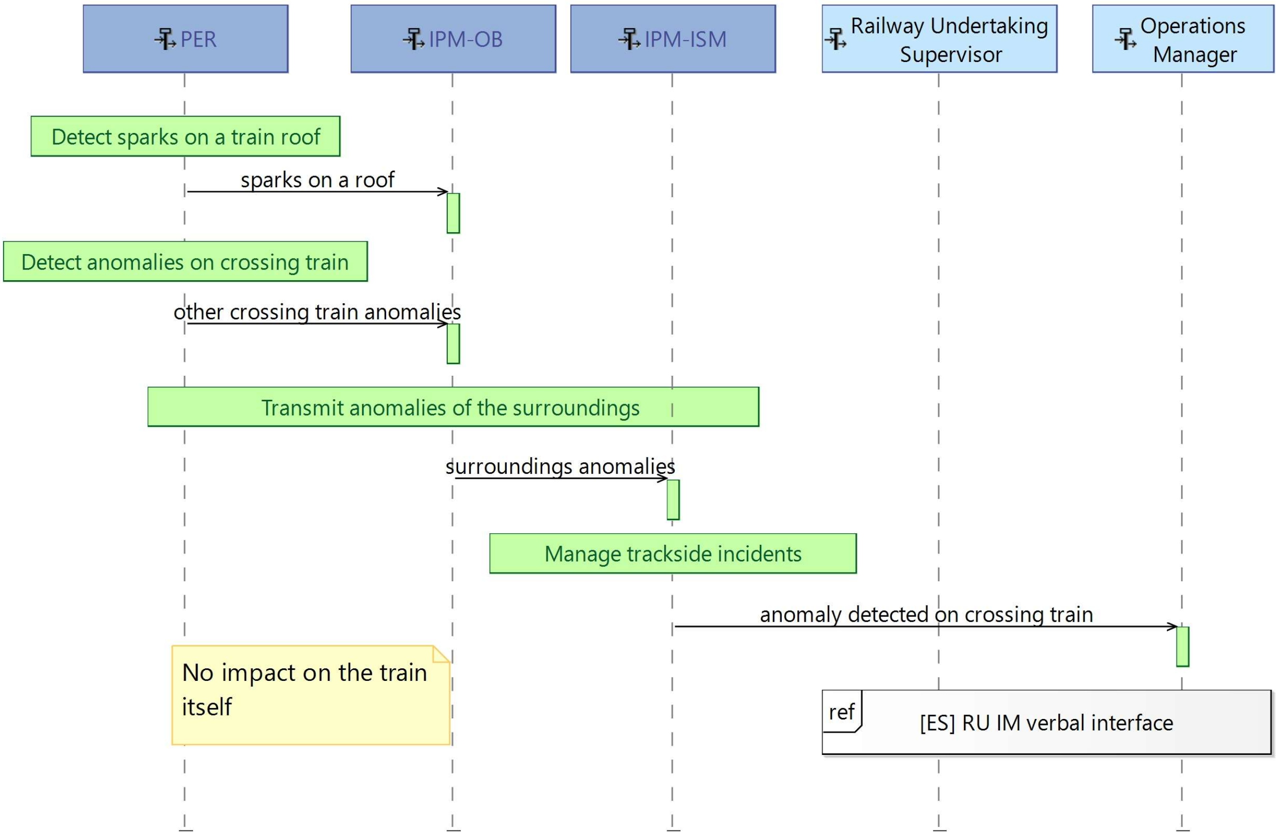
## Description

The detection of a bogie instability can be used to avoid a derailment. In case of failure of the detection system, a speed limit must be enforced.



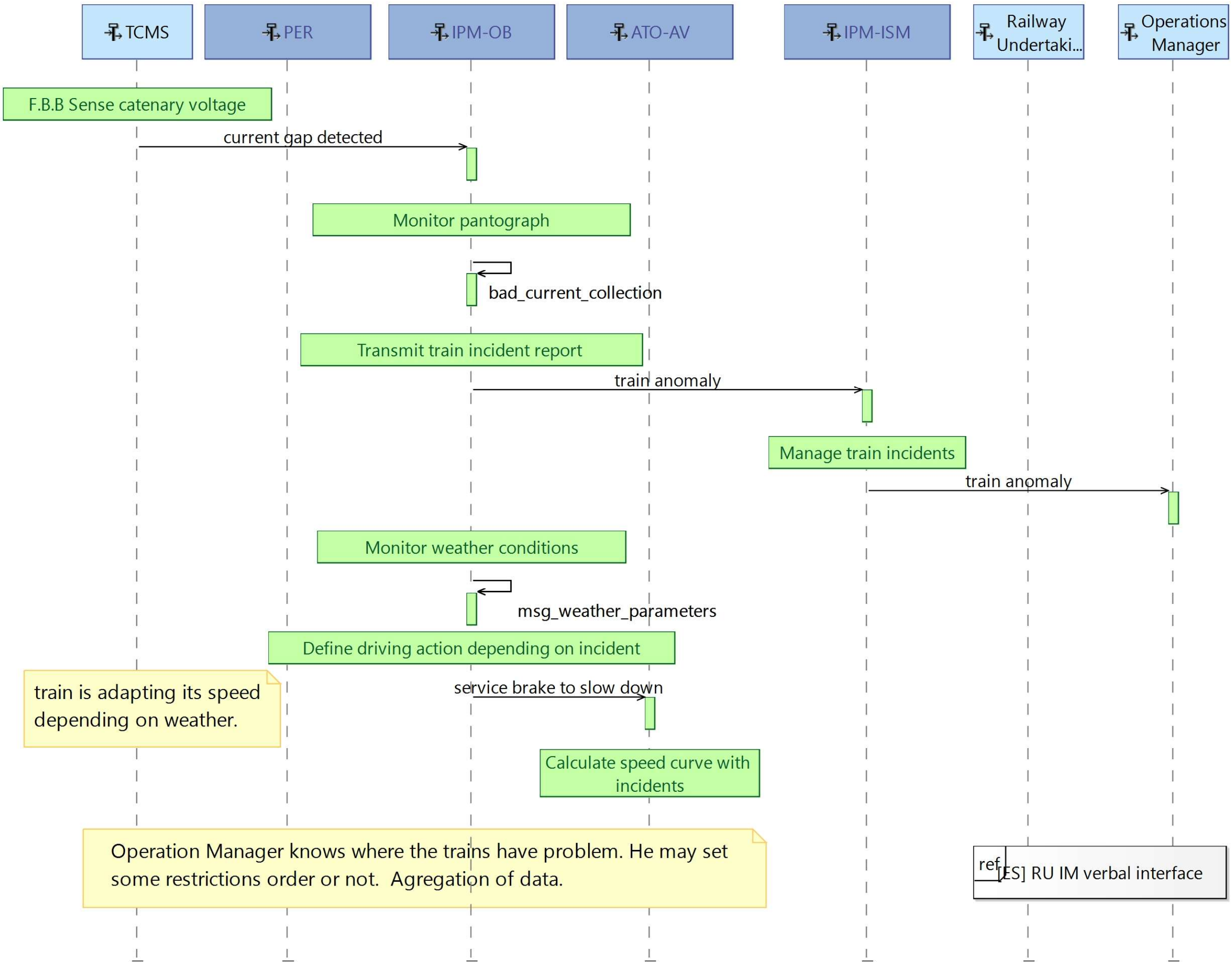
### 12.9.6 Other train circulating under dangerous conditions

This Use Case details the actions to be taken in case of anomalies detected on a neighbour train.



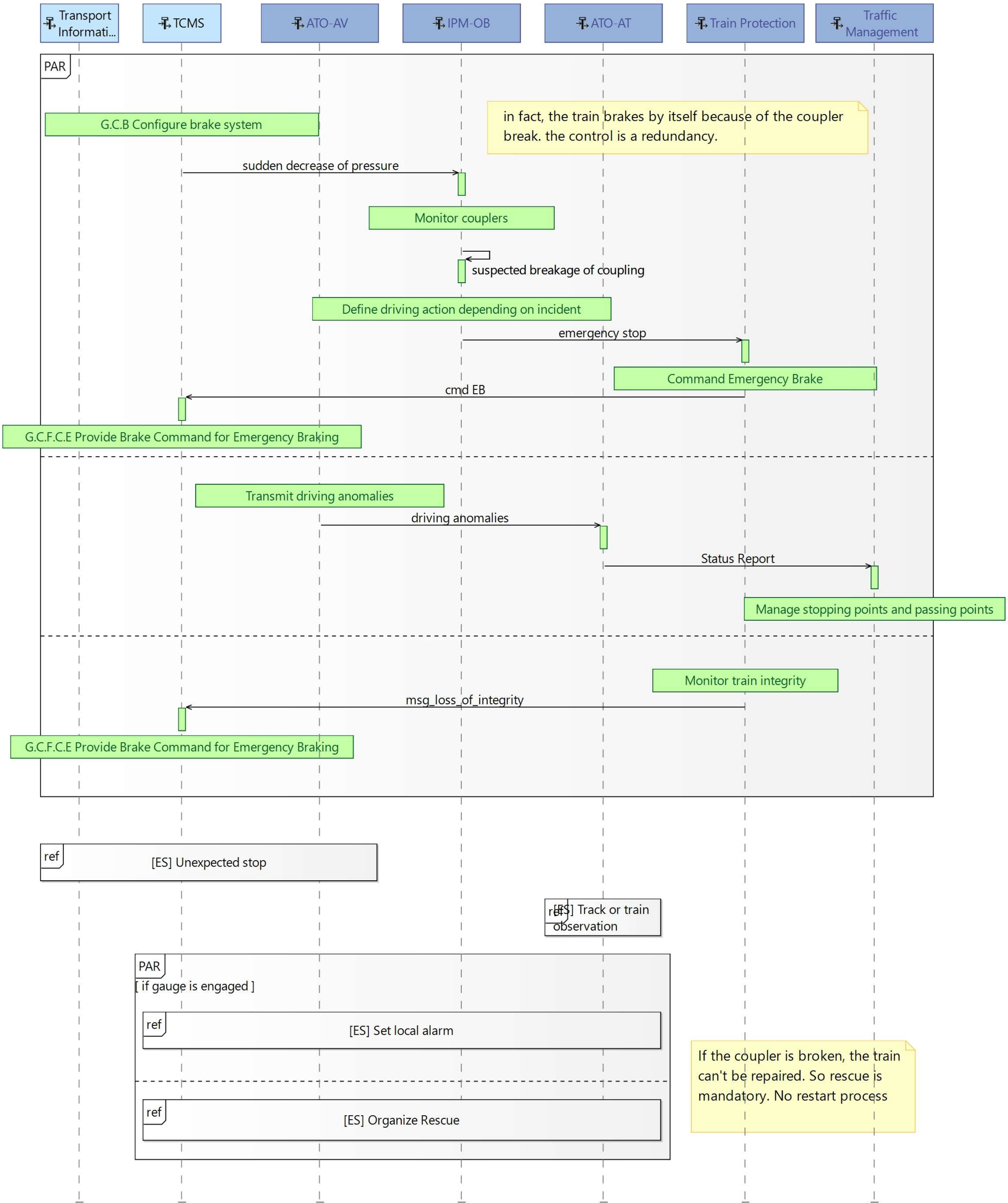

### 12.9.7 Bad current collection in case of bad weather conditions

This Use Case details the actions to be taken in case of bad current collection.




## 12.9.8 Train separation (loss of integrity)

This Use Case details the actions to be taken in case of loss of integrity.

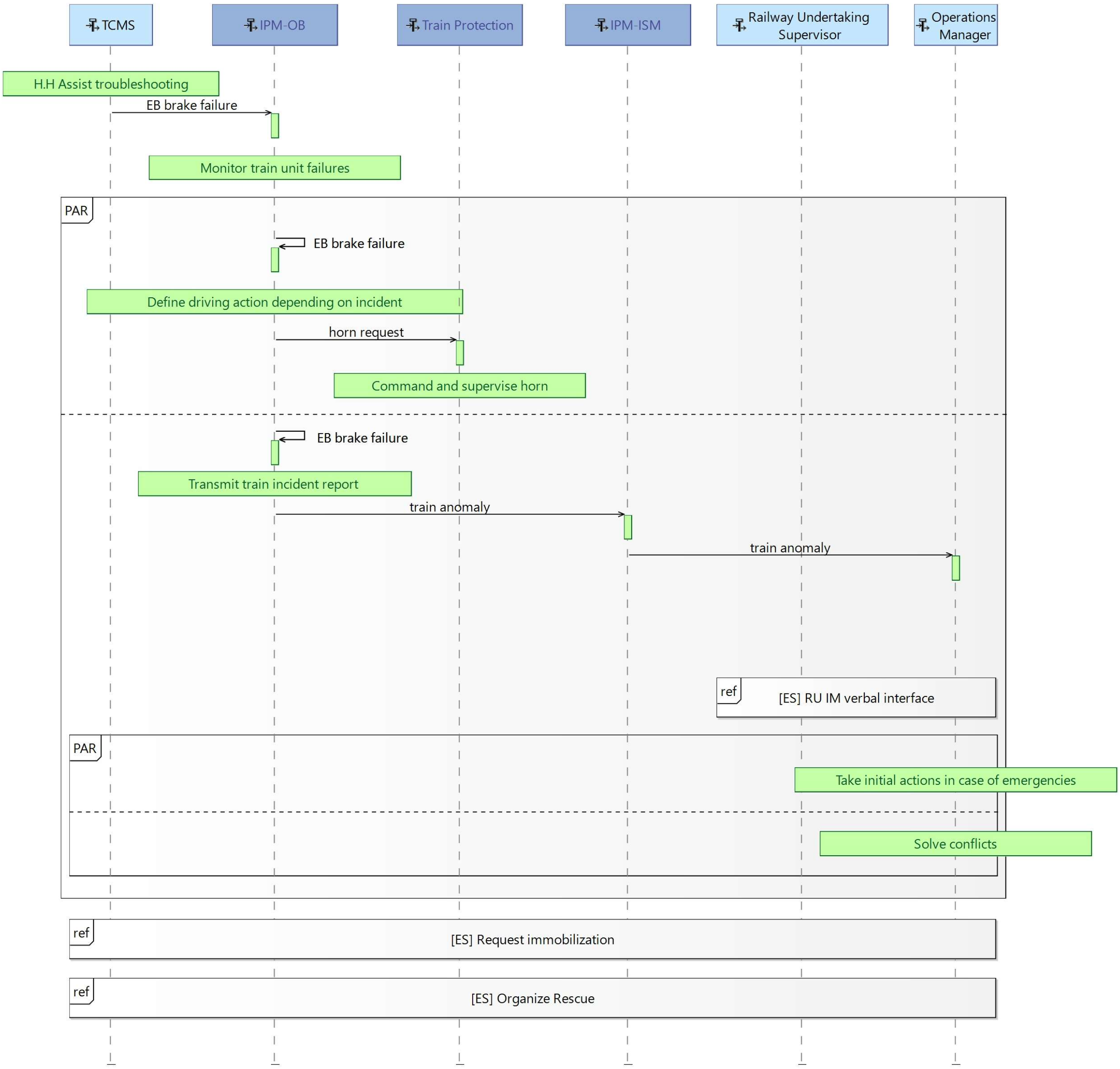



### 12.9.9 Uncontrollable movement by Emergency Brake failure

This Use Case details the actions to be taken in case of failure of EB command.

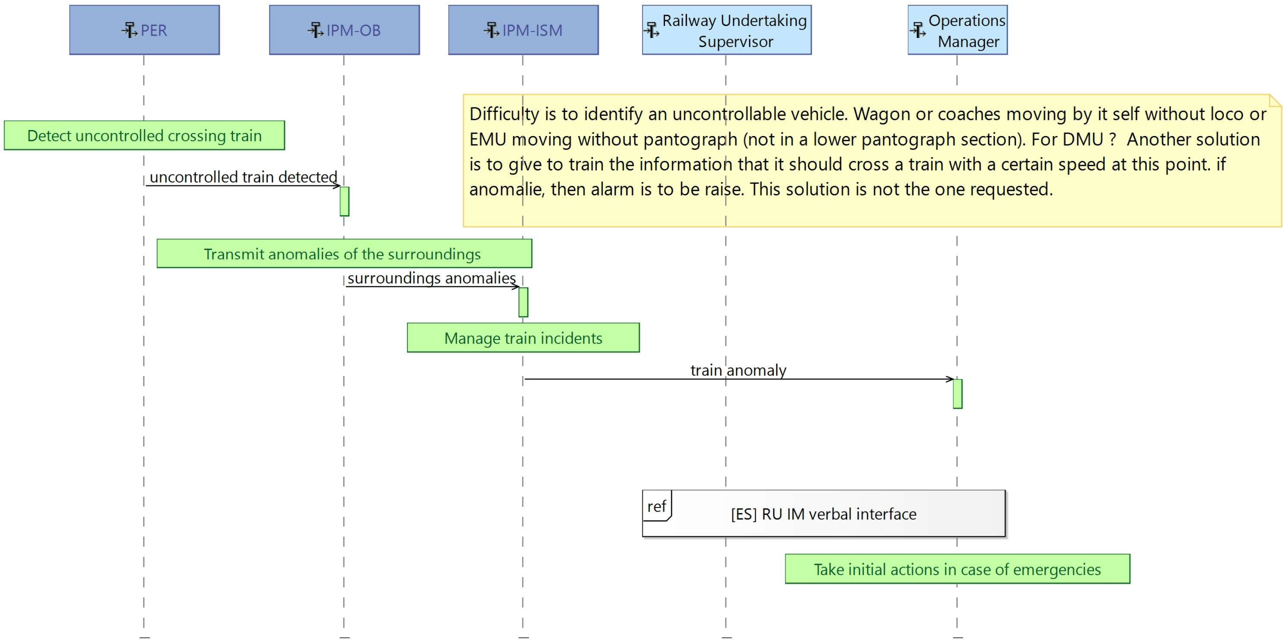
## Description

This Use Case is a last safety net with horn and reporting to control centre for deviating the train and warning the other trains.



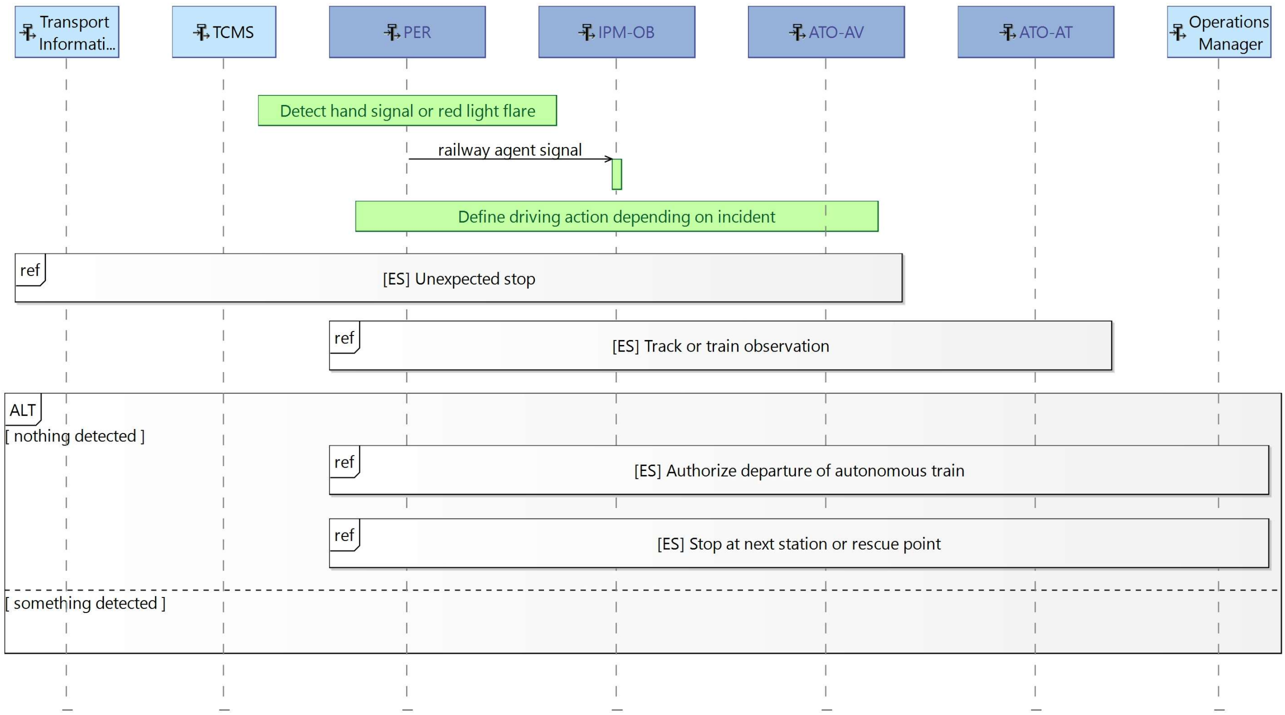

### 12.9.10 Uncontrollable movement of uncontrollable vehicles

This Use Case details the actions to be taken in case of abnormal movement of a neighbour train.




## 12.9.11 Perception of non-autonomous train local alarms

This Use Case details the actions to be taken in case a local alarm is sent by a neighbour train.

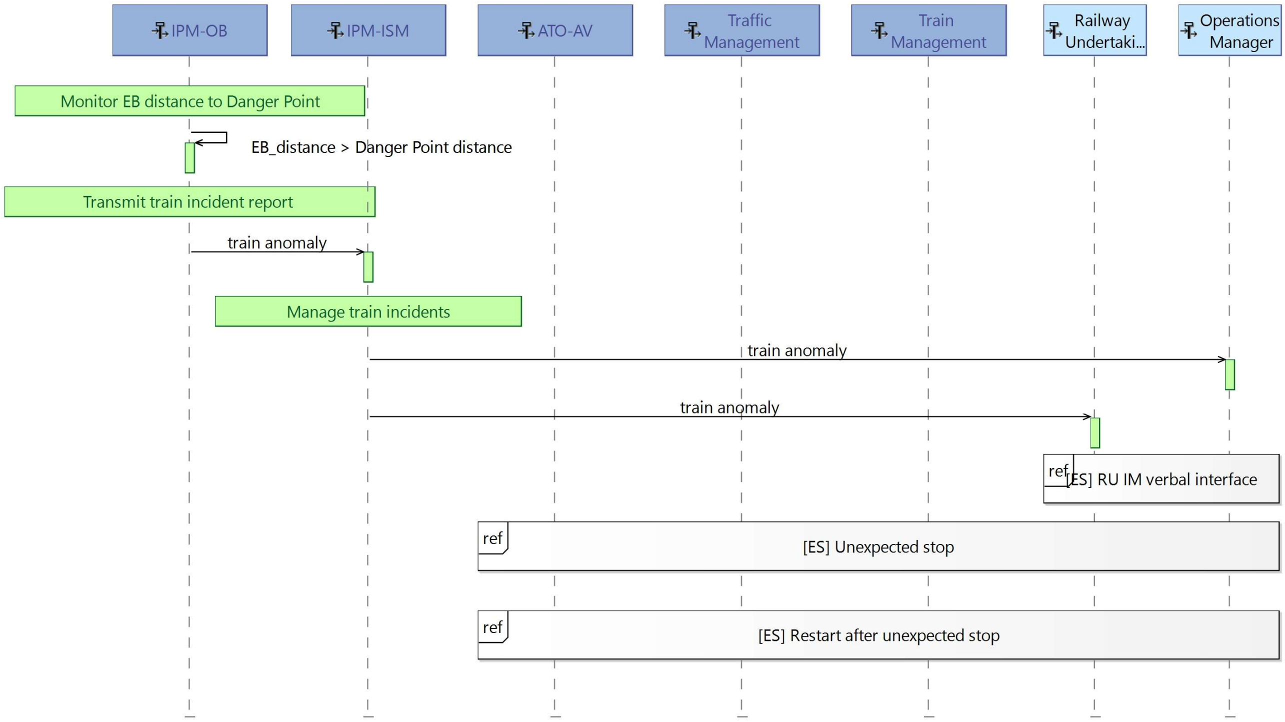



## 12.9.12 Passing a Danger Point due to a too long brake sequence

This Use Case details the actions related to an emergency situation.

Description

The purpose of this UC is to report an abnormal event in case of brake failure. Such event should not happen however reporting permits to take emergency actions for deviating the train and warning the other trains.



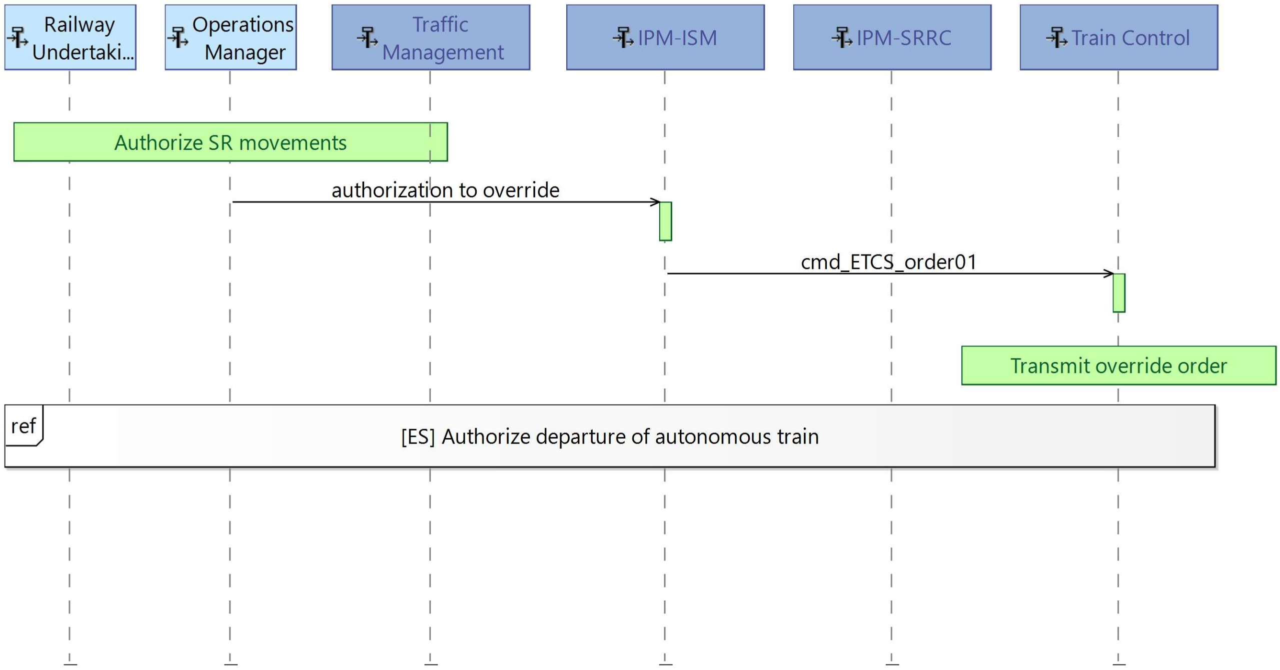

### 12.9.13 Override process

This Use Case details the override procedure.

Description

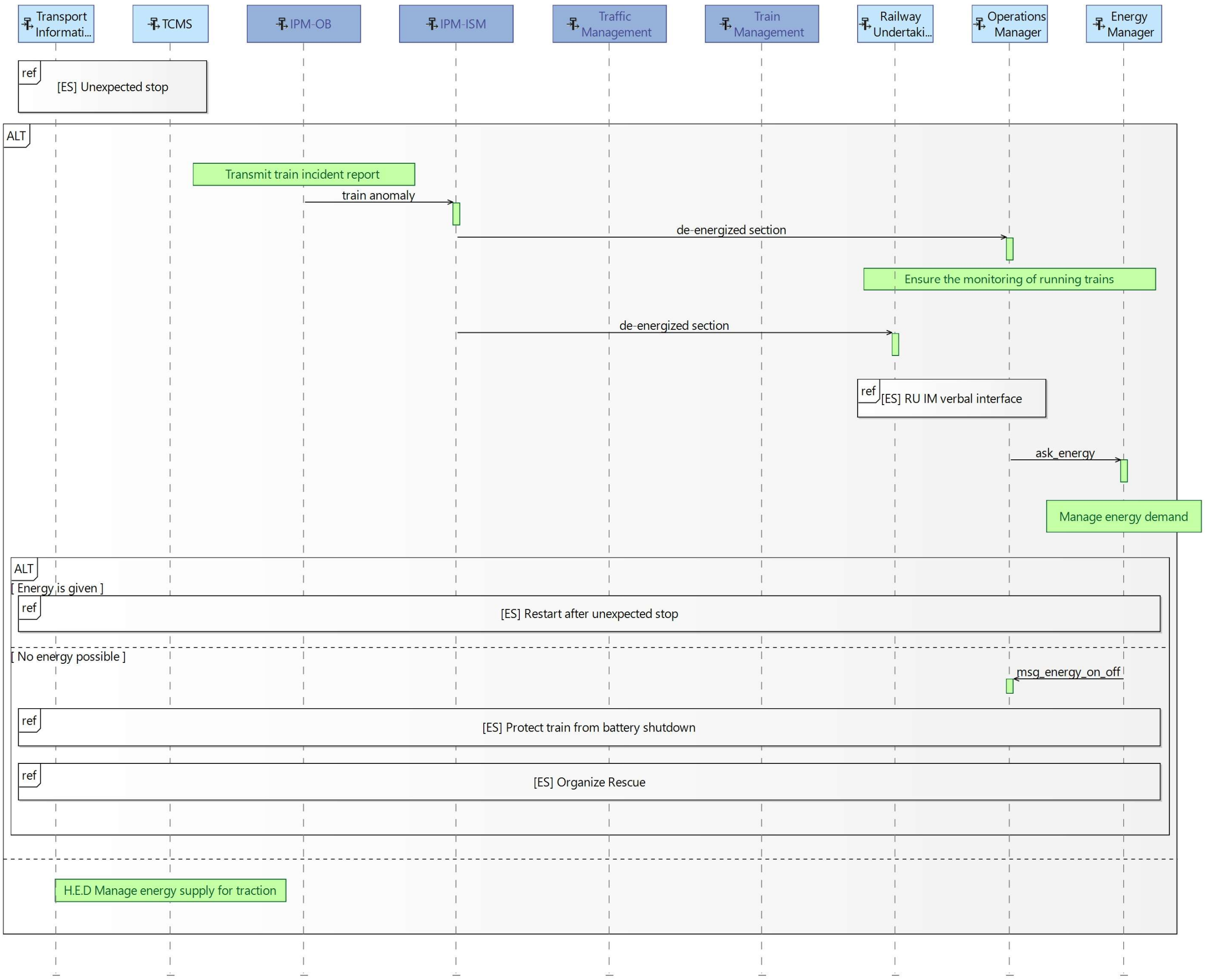
This procedure permits onboard ETCS to pass an EOA with ETCS Written Order 01 (Permission to pass an EOA) without intervention from the driver. IPM channel is an alternative to Train Control/Train Protection channel.

Note: This procedure is not foreseen for a start of mission where FS mode is expected in the nominal case. Degraded situation is currently not detailed (for example, TAF button from driver could be replaced with a function involving obstacle detection).



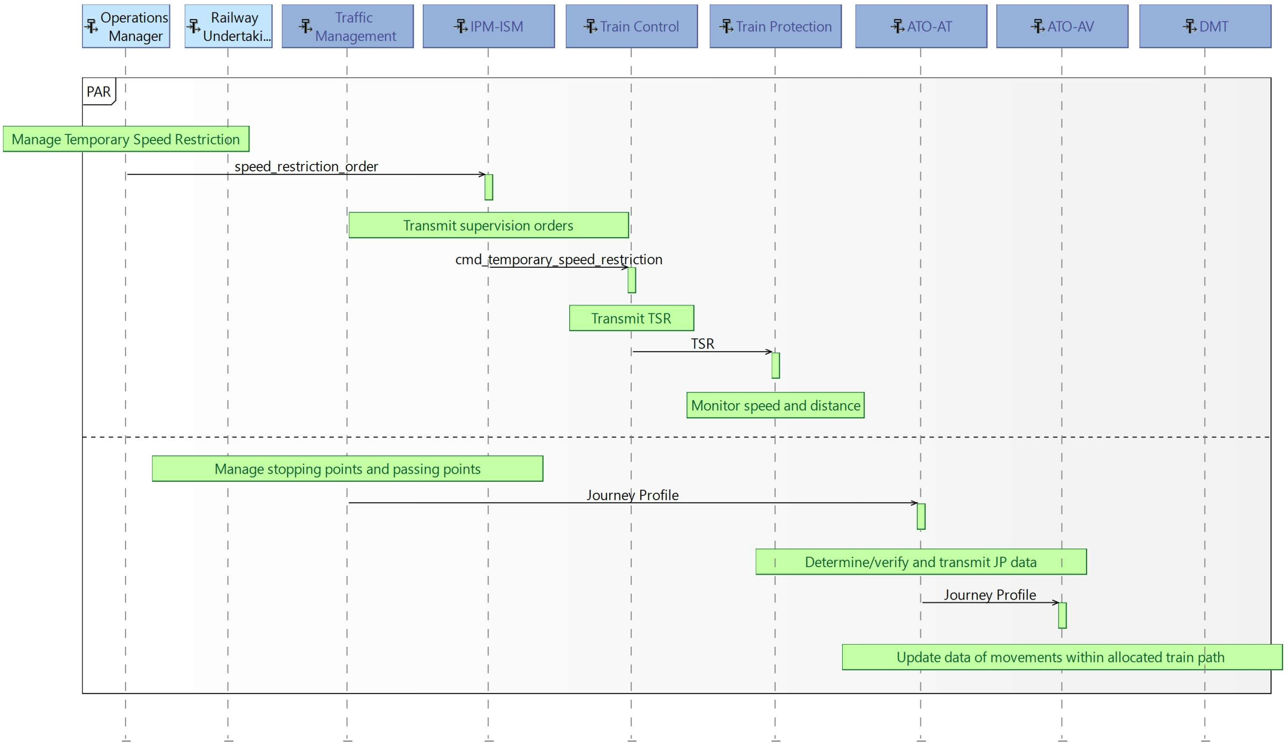

### 12.9.14 Unforeseen stop in de-energized section

This Use Case details the actions to be taken in case the train is stopped in a neutral section.




## 12.9.15 Speed restriction due to weather conditions

This Use Case details the actions to be taken in case of bad weather detection.




### 12.9.16 Manage adhesion problems

This Use Case details the actions related to a track with low adhesion.

Description

Under GoA2 operation, the adhesion information from the trains is sent to the trackside. This adhesion information is sent to the other trains on this track via ATO-AT and Train Control. ATO-AV can optimise the driving and journey for the applicable adhesion and Train Protection protects the movement for the applicable adhesion conditions.

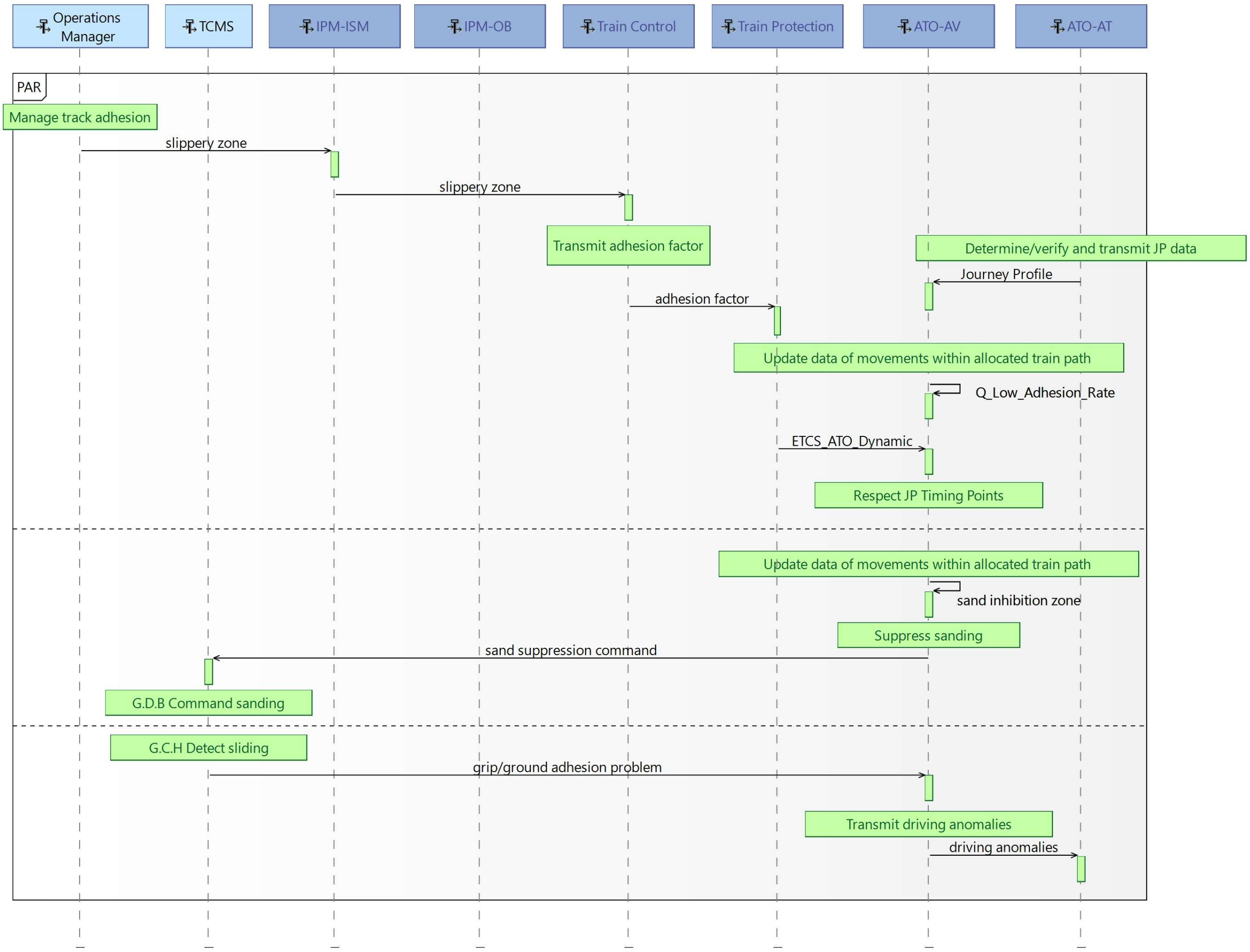
In GoA4, a feedback loop provided by IPM-OB and IPM trackside could be used to record a low adhesion area until trains passing on it do not report any more a low adhesion.

Final solution is not yet defined. Safety should be managed by ETCS while performance should be managed by ATO. TCMS low adhesion information should be standardized to ensure interoperability. Currently, it is limited to slip/slide detection with an important operational impact if each detection is followed by a low adhesion area. An alternative is to define the track adhesion profile with several sources of information like currently investigated within the Pinta project. PER will not be used to detect leaves on the track, it is a seasonal information available in DM and managed by track maintenance staff.

The CR S125-189 will be used for the moment:

7.6.1.2 When the ATO-OB is informed about «slip/slide adhesion factor» from an external system, this information shall be sent to the ATO-TS.

7.6.1.4 The ATO-OB shall adapt the ATO Operational Speed Profile and traction / braking commands according to the «low adhesion information adhesion category» transmitted via the Journey Profile.




## 12.10React to rolling stock related incidents

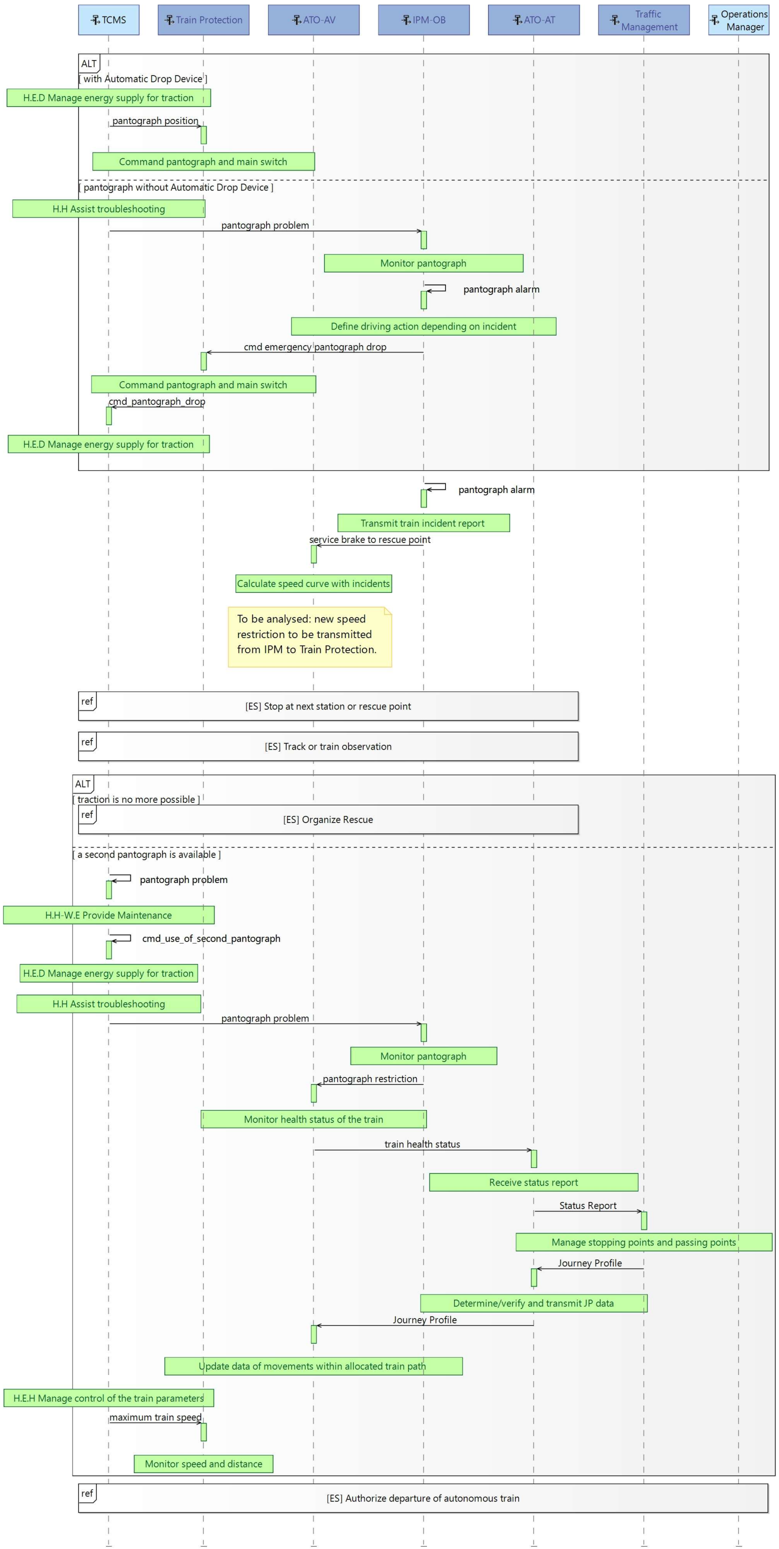
### 12.10.1 Damage to pantograph

This Use Case details the actions to be taken in case of pantograph damage.

<u>Description</u>

First reaction is to drop the pantograph before to stop at next station or rescue point under the protection of ETCS.

In case a second pantograph is available, restart will be done with the new train maximum speed communicated by TCMS and supervised by ETCS after a change of train data at standstill (this procedure 5.17 of SS-026 is not represented on the sequence diagram).



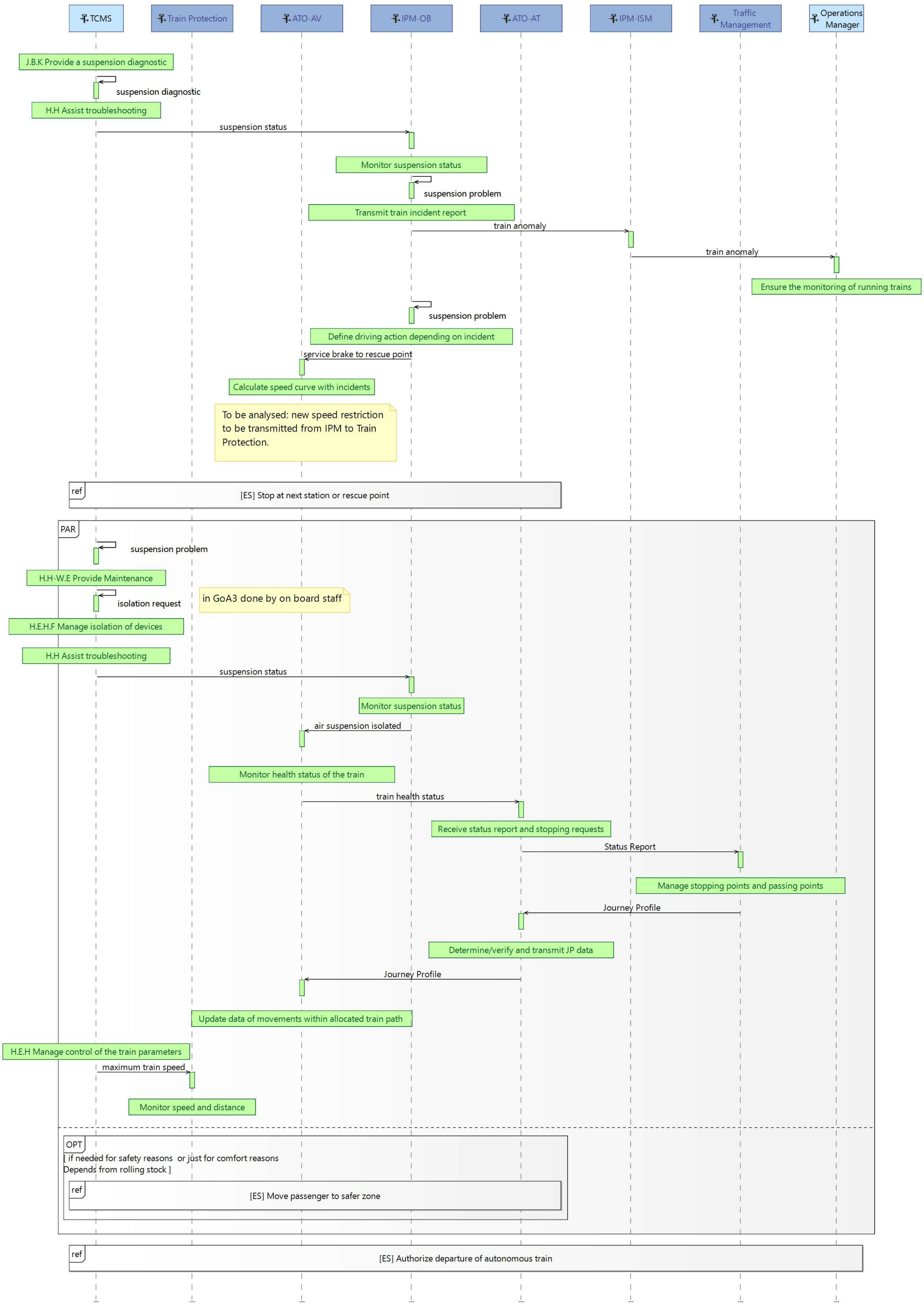

### 12.10.2 Air Suspension Damage

This Use Case details the actions to be taken in case of air suspension damage.

Description

First reaction is to stop at next station or rescue point under the protection of ETCS.

Restart will be done with the new train maximum speed communicated by TCMS and supervised by ETCS after a change of train data at standstill (this procedure 5.17 of SS-026 is not represented on the sequence diagram).



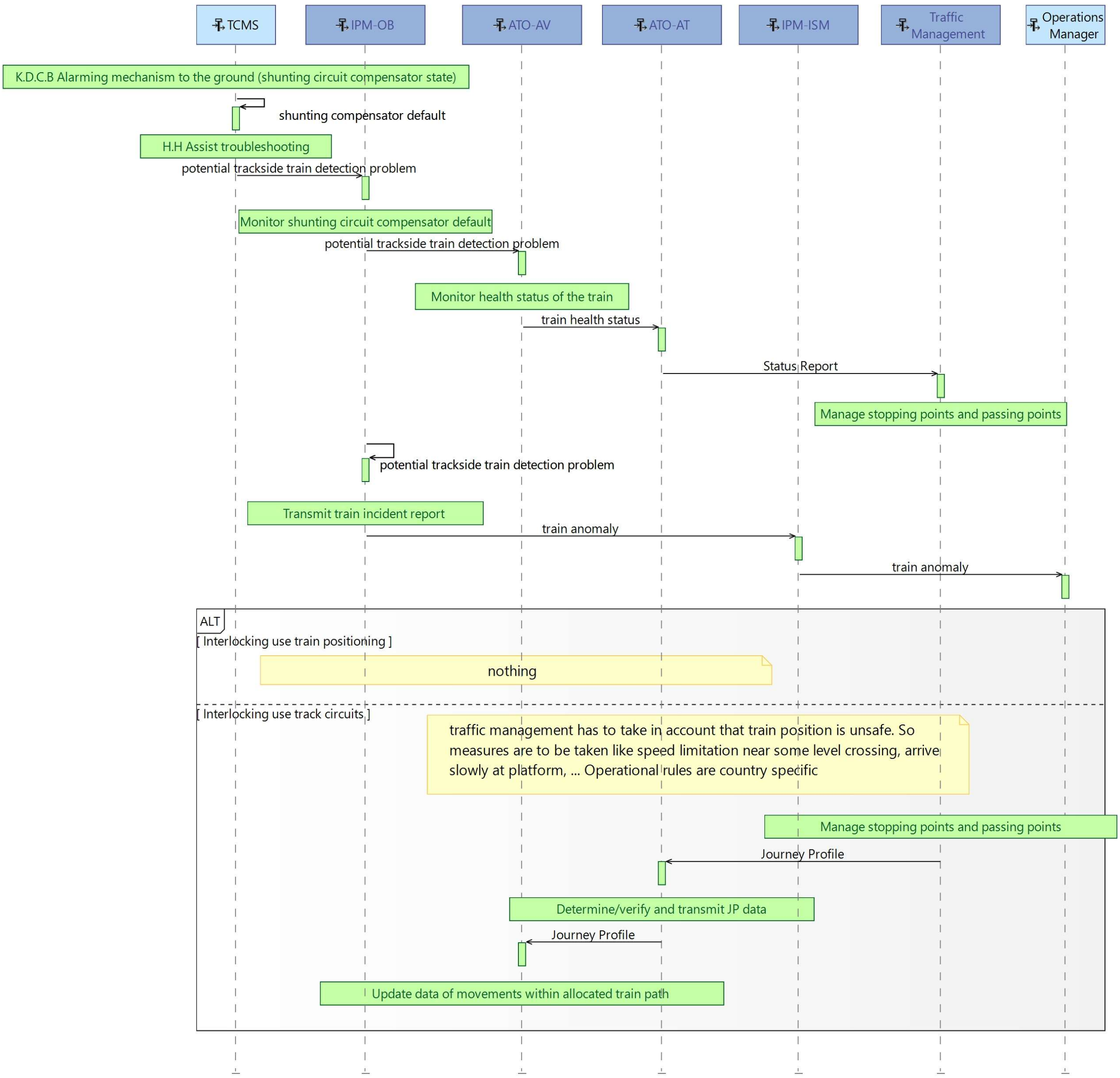

### 12.10.3 Shunting Circuit Compensator Default

This Use Case details the actions to be taken in case of shunting circuit compensator default.

Description

Today, a default of shunting compensator onboard device is indicated to the driver. IM must react because it means that the train can be far away from the last position detected by track-circuits.

This use case depends on the train, it is foreseen for light trains but not heavy trains.

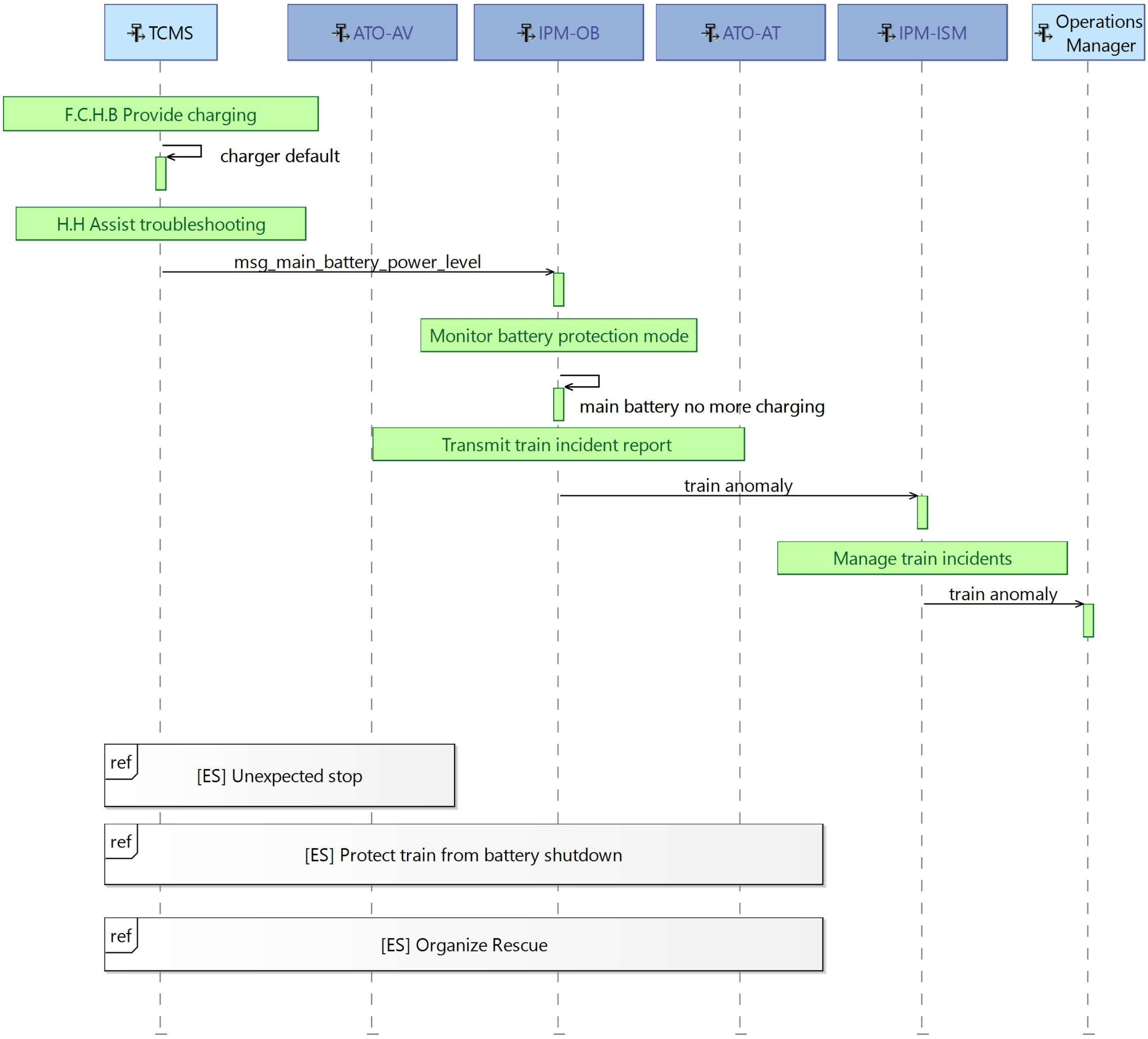



### 12.10.4 Main Battery Protection

This Use Case details the actions to be taken in case of battery charger default.

Description

Aim is to protect the train before battery get protected to avoid any runaway situation.

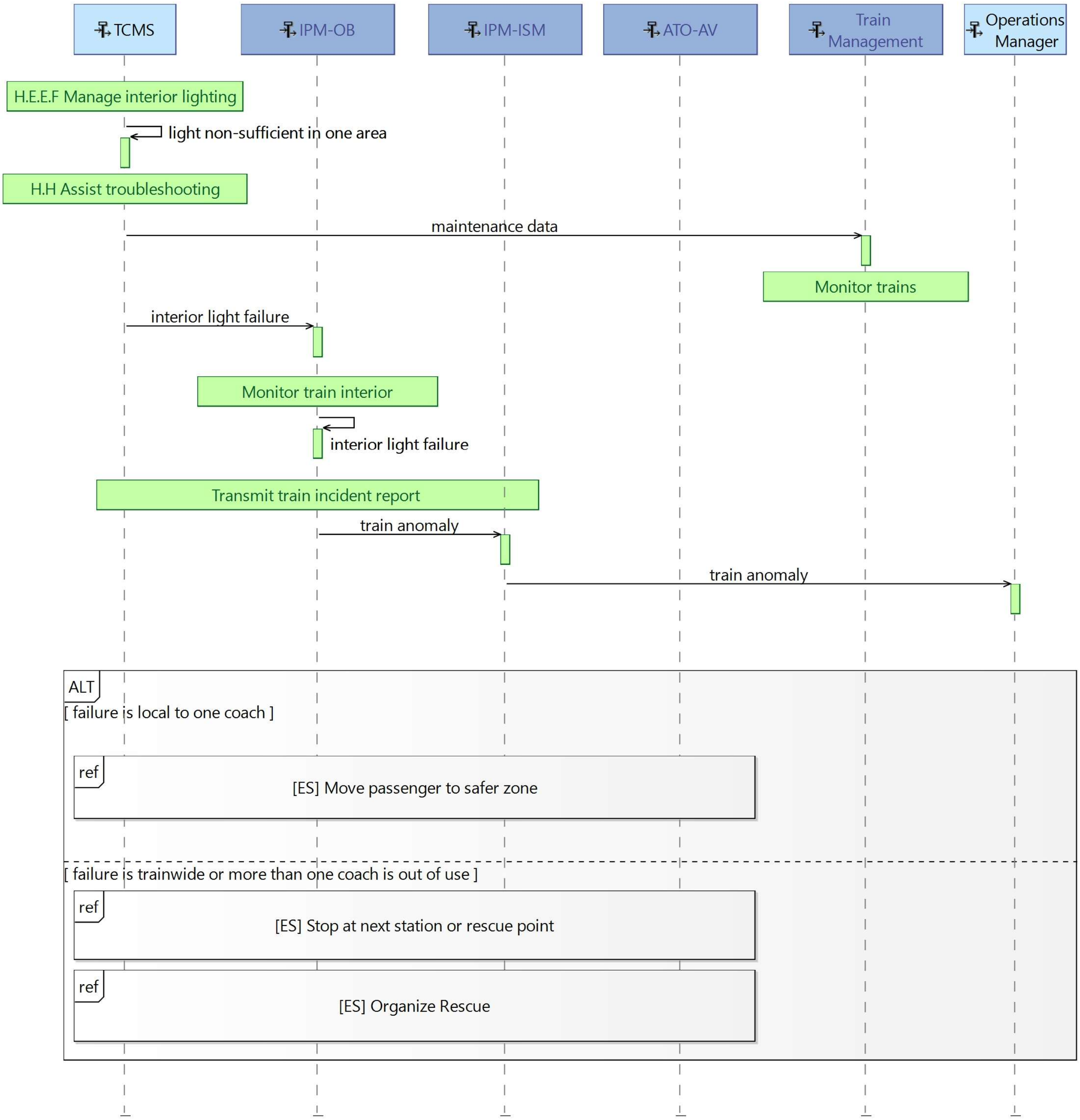



### 12.10.5 Interior Lighting Default

This Use Case details the actions to be taken in case of light level below 70% in a coach.

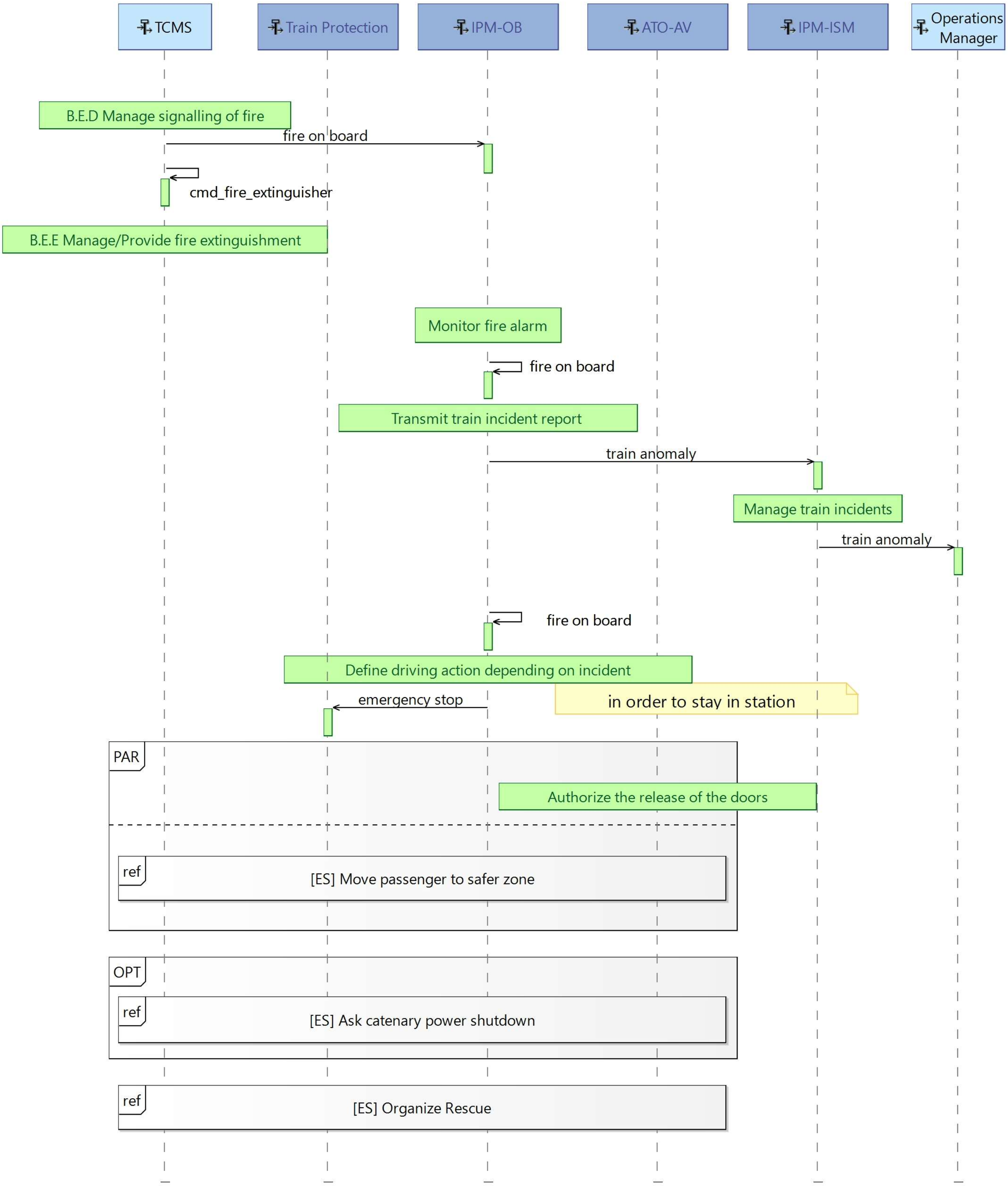
Description

A failure of interior lighting is a train failure that must be managed by TCMS and reported to Train Management. The reaction can only be managed by RU, it cannot depend on a trackside implementation.



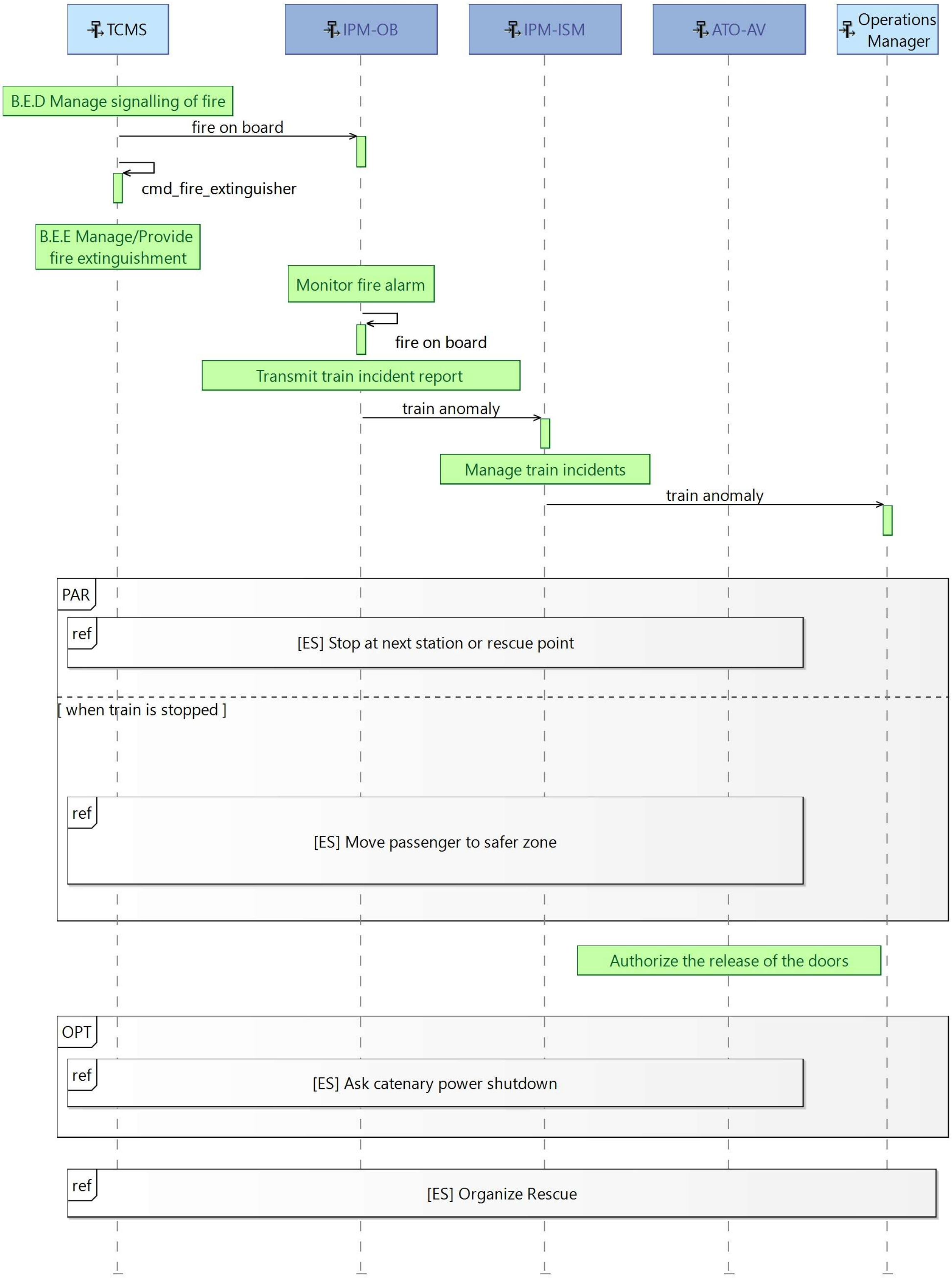

### 12.10.6 Fire on Board in station

This Use Case details the actions to be taken in case of fire detection in station.




### 12.10.7 Fire on Board while running

This Use Case details the actions to be taken in case of fire detection while running.

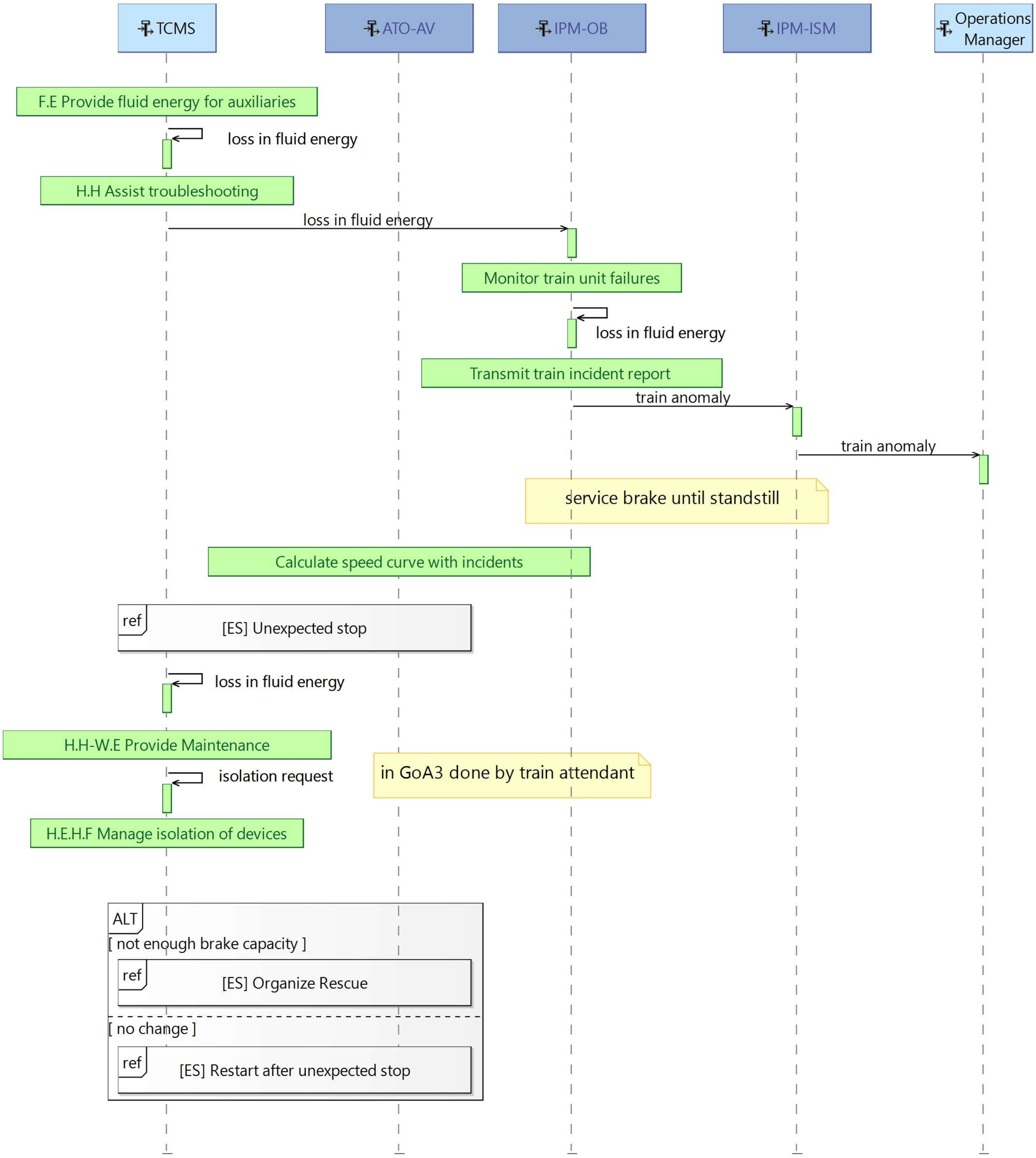



### 12.10.8 Failure in fluid energy for auxiliaries process

This Use Case details the actions to be taken in case of leak in pneumatic or hydraulic circuits.

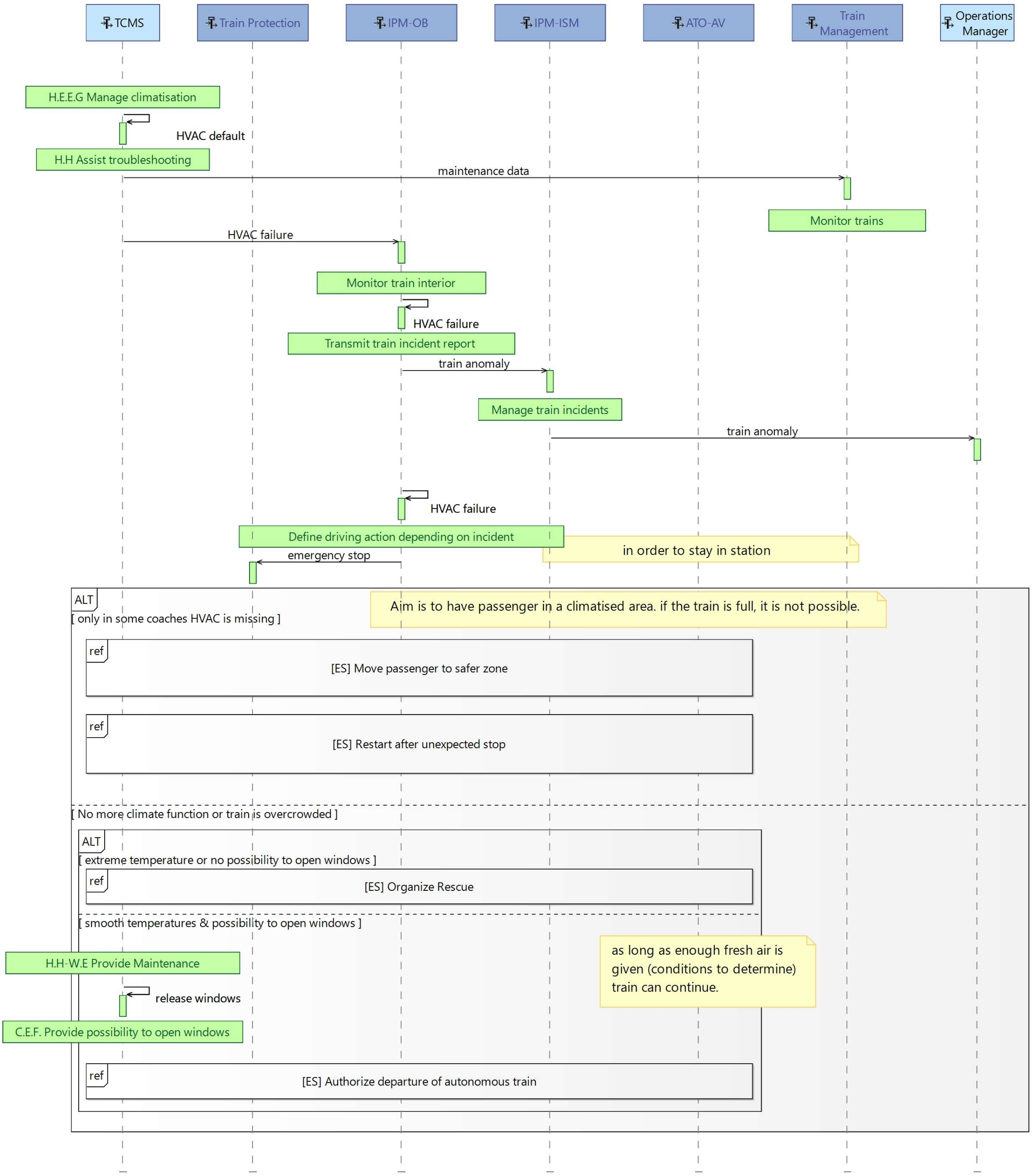
Description

if the fluid energy is too low, consequences are loss of brake efficiency, no possibility to raise pantograph or no possibility to open /close door.



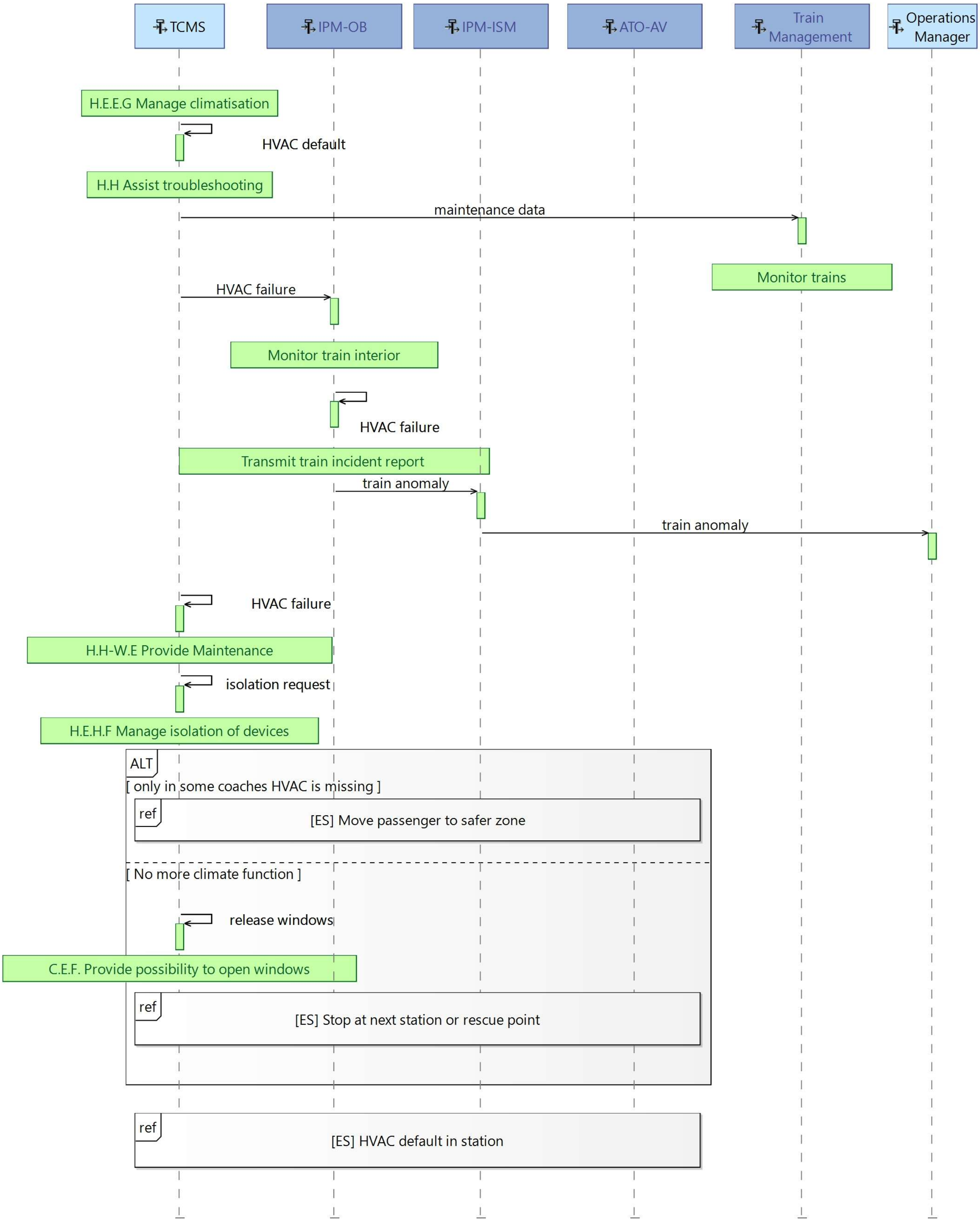
### 12.10.9 HVAC default in station

This Use Case details the actions to be taken in case of HVAC default in station.



### 12.10.10 HVAC default while running

This Use Case details the actions to be taken in case of HVAC default while running.



### 12.10.11 Hot Box Alarm from trackside

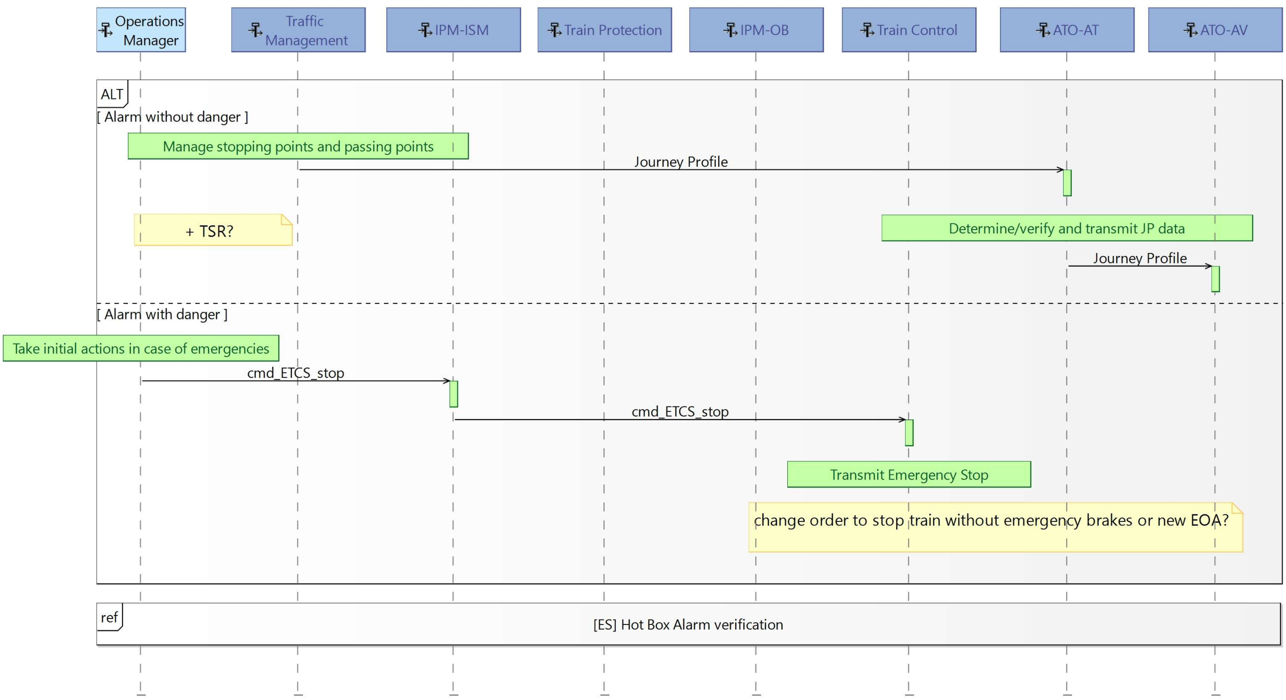
This Use Case details the actions to be taken in case of hot box detection (trackside sensor).

Description

Trackside monitoring of hot box permits to detect an increase of temperature at specific locations. The first reaction is to reduce the train speed until a stop at a rescue point to check what happened (false alarm or blocked axle).

If the temperature increase is too high, the situation is dangerous and full service brake must be applied until stop. An action on emergency brakes is not suitable because it could lead to a derailment.

It is expected that GoA34 trains can manage an equivalent perception by themselves (continuous supervision like for a TGV). Both systems should be complementary, especially in case of mixed traffic.




### 12.10.12 Hot Box Alarm from on board sensor

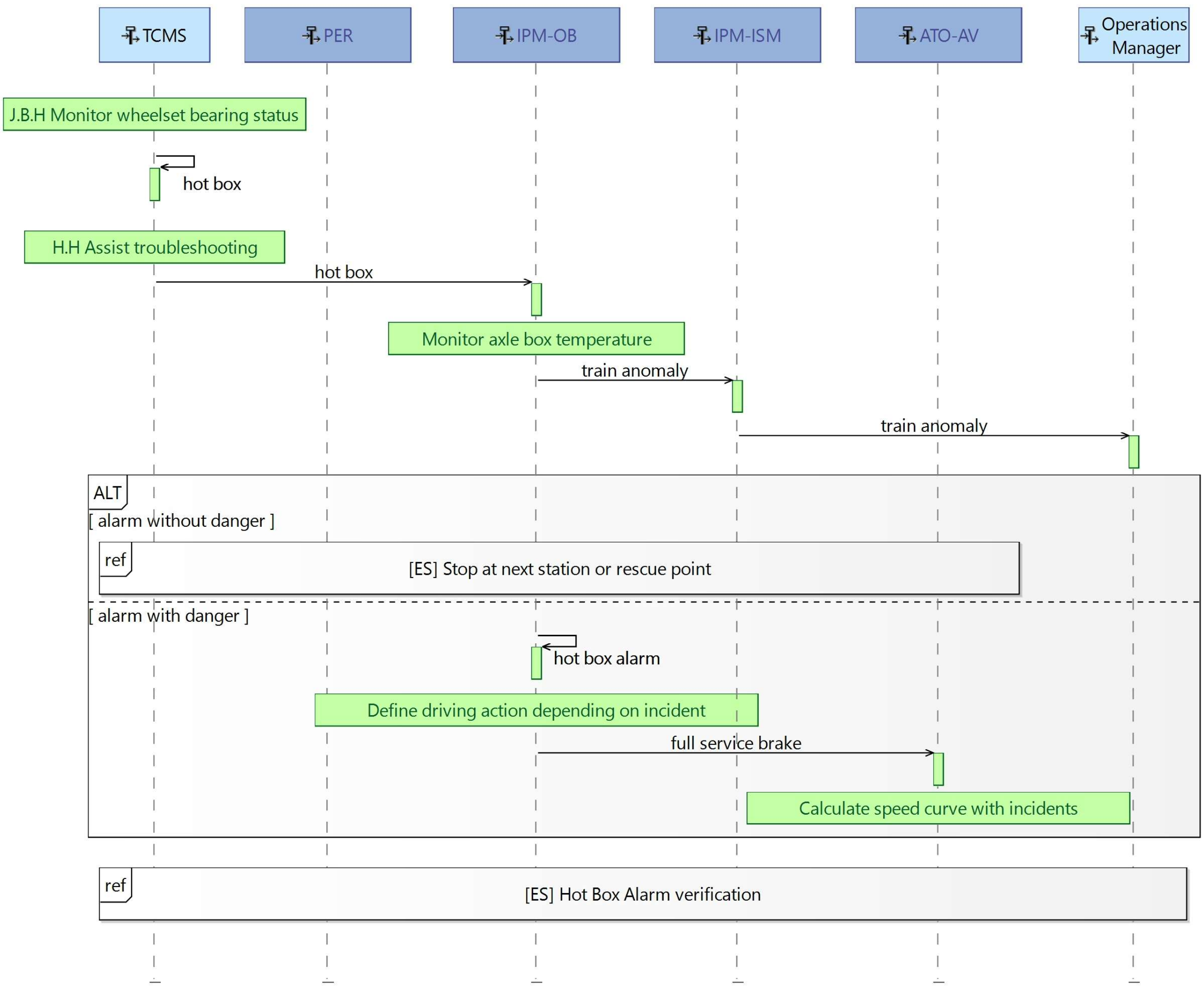
This Use Case details the actions to be taken in case of hot box detection (onboard sensor).

Description

Onboard monitoring of hot box permits to detect quickly an increase of temperature. The first reaction is to reduce the train speed until a stop at a rescue point to check what happened (false alarm or blocked axle).

If the temperature increase is too high, the situation is dangerous and full service brake must be applied until stop. An action on emergency brakes is not suitable because it could lead to a derailment.

See Monitor axle box temperature description and UC move locally the train for more details. TCMS provides first information and a local control of the axle by sensor at low speed is necessary to check the hot axle.

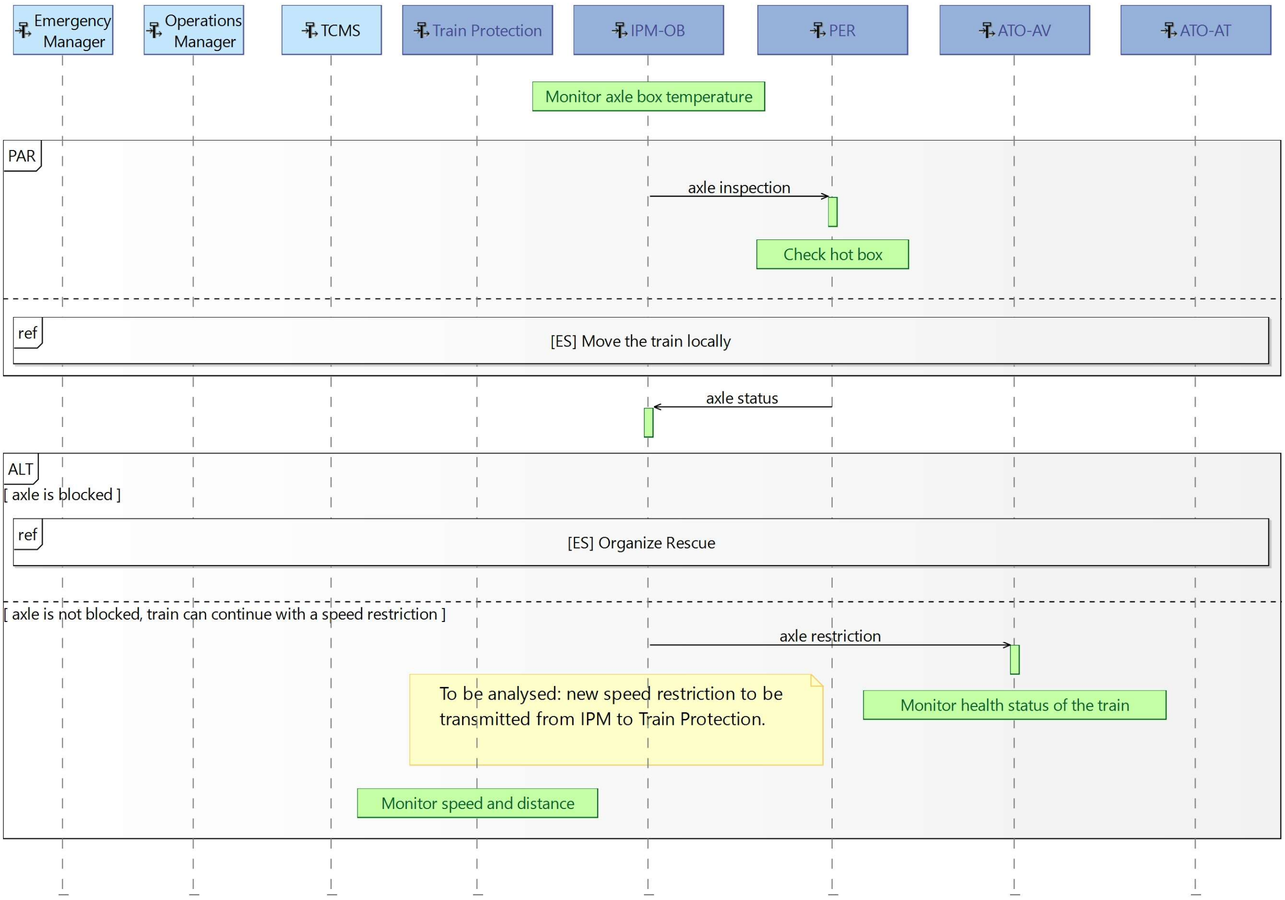



### 12.10.13 Hot Box Alarm verification

This Use Case details the actions to be taken in case of hot box detection (verification at low speed).

<u>Description</u>

After a train stop caused by hot box detection, it is necessary to check if an axle is blocked or not. A short movement controlled by local emergency staff with local perception permits to determine if the axle moves or not. If yes, the mission can continue with a speed restriction given by IPM. If not, a rescue train is necessary.



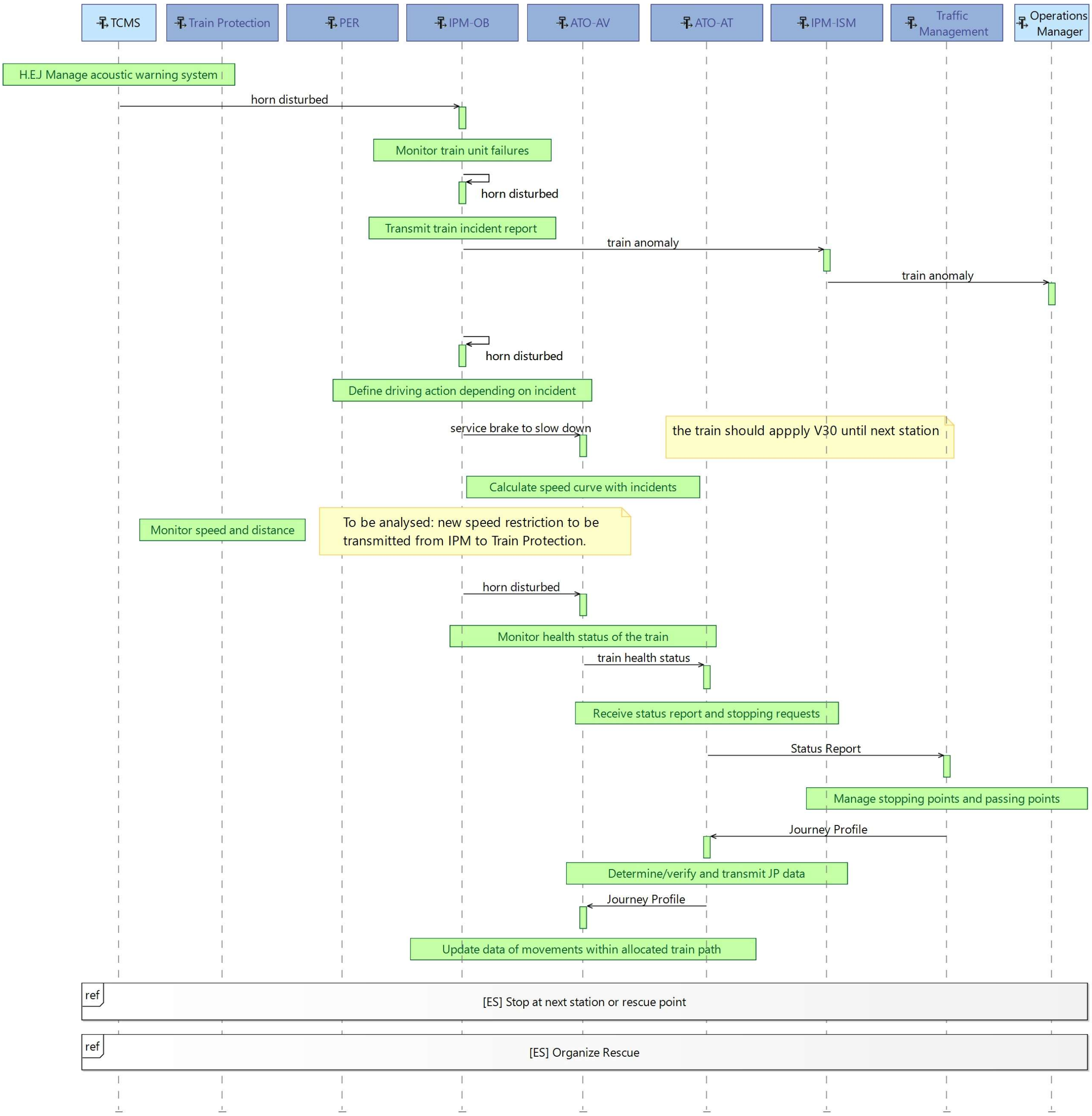

## 12.10.14 Horn Default

This Use Case details the actions to be taken in case of horn default.

Description

First reaction is to slow down to a configurable speed given by IPM (30 km/h for example) under the protection of ETCS.

Then, it is required to stop at next station or rescue point.

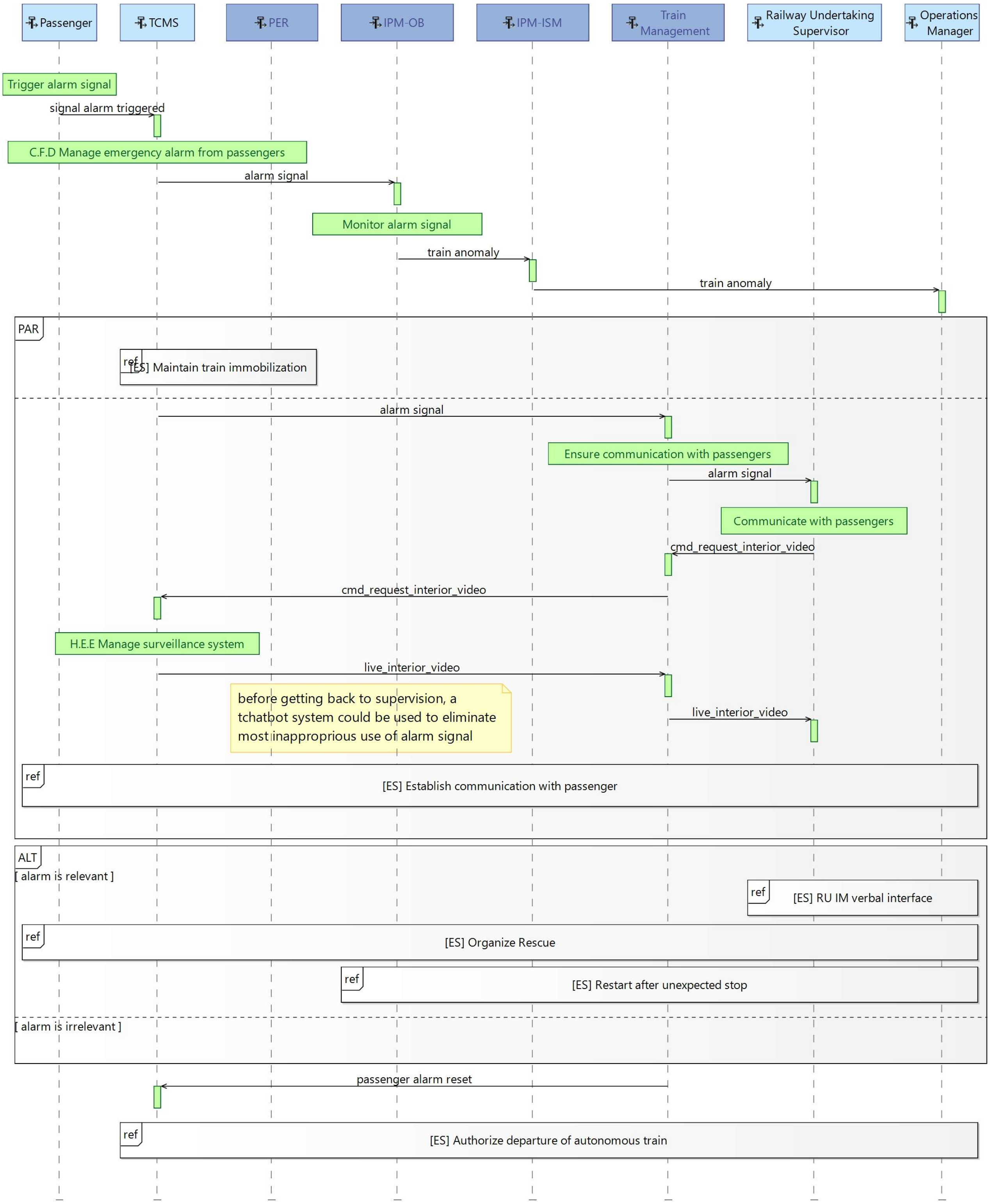



### 12.10.15 Use of Alarm Signal in station

This Use Case details the actions to be taken in case of alarm triggered by passengers in station.

<u>Description</u>

The alarm signal corresponds to the passenger alarm in case of emergency situation. When triggered in a station, it must lead to train immobilisation. Train management must be informed and will reset the alarm after evaluation through CCTV images and voice communication with passengers.


Passenger
TCMS
PER
IPM-OB
IPM-ISM
Train Management
Railway Undertaking Supervisor
Operations Manager
Trigger alarm signal
signal alarm triggered
C.F.D Manage emergency alarm from passengers
alarm signal
Monitor alarm signal
train anomaly
train anomaly
PAR
ref
[ES] Maintain train immobilization
alarm signal
Ensure communication with passengers
alarm signal
Communicate with passengers
cmd_request_interior_video
cmd_request_interior_video
H.E.E Manage surveillance system
live_interior_video
before getting back to supervision, a tchatbot system could be used to eliminate most inapproprious use of alarm signal
live_interior_video
ref
[ES] Establish communication with passenger
ALT
[ alarm is relevant ]
ref
[ES] RU IM verbal interface
ref
[ES] Organize Rescue
ref
[ES] Restart after unexpected stop
[ alarm is irrelevant ]
passenger alarm reset
ref
[ES] Authorize departure of autonomous train

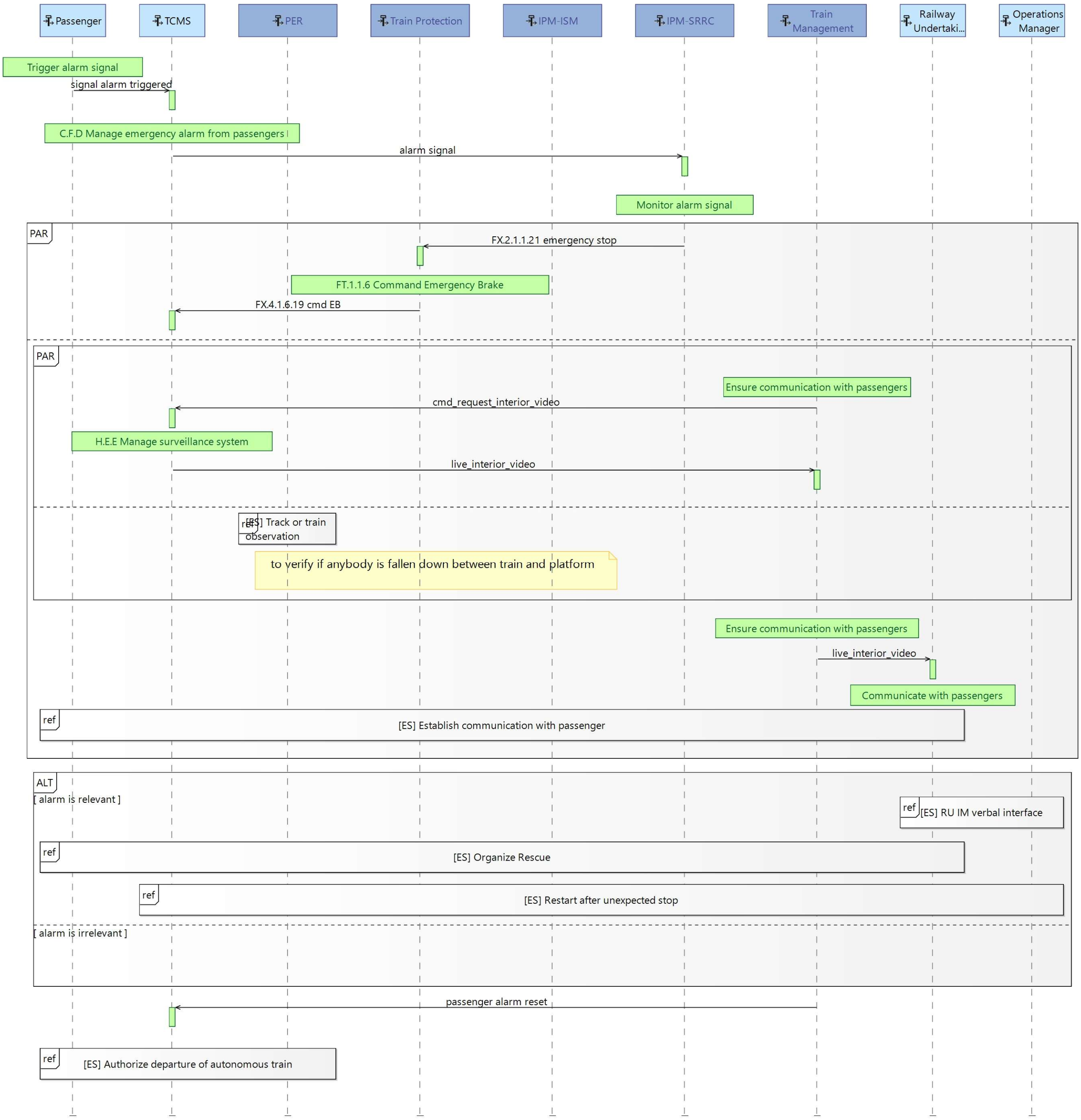
### 12.10.16 Use of Alarm Signal when train is starting (train still along platform)

This Use Case details the actions to be taken in case of alarm triggered by passengers at train departure.

Description

The alarm signal corresponds to the passenger alarm in case of emergency situation. When triggered during a train departure in station, it could be caused by the fall of a passenger and IPM will trigger Emergency Brake.

Train management must be informed and will reset the alarm after evaluation through CCTV images and voice communication with passengers.

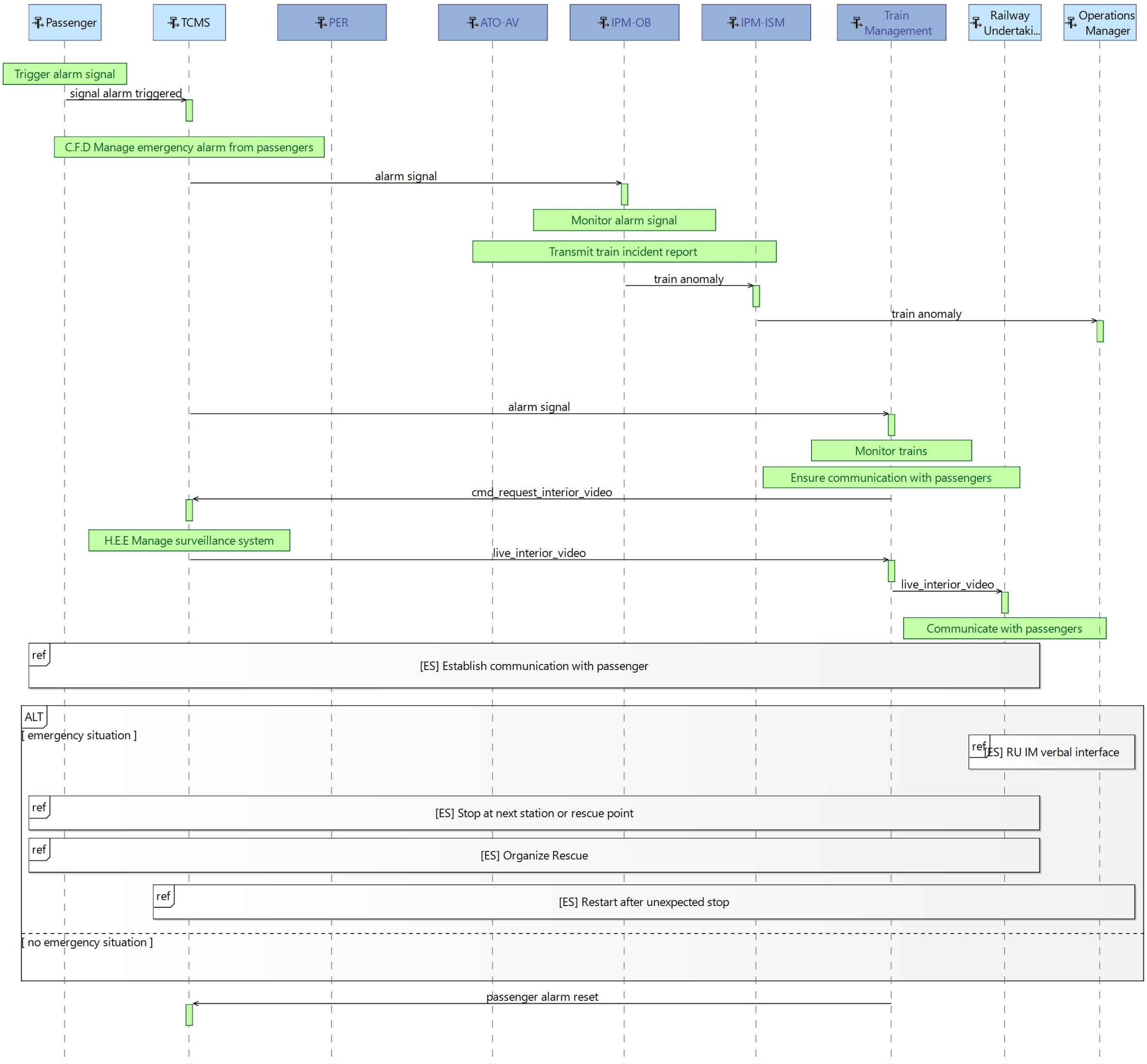



### 12.10.17 Use of Alarm Signal during train run

This Use Case details the actions to be taken in case of alarm triggered by passengers during train run.

Description

The alarm signal corresponds to the passenger alarm in case of emergency situation. IPM will not stop the train in this case. Train management must be informed and will reset the alarm after evaluation through CCTV images and voice communication with passengers.

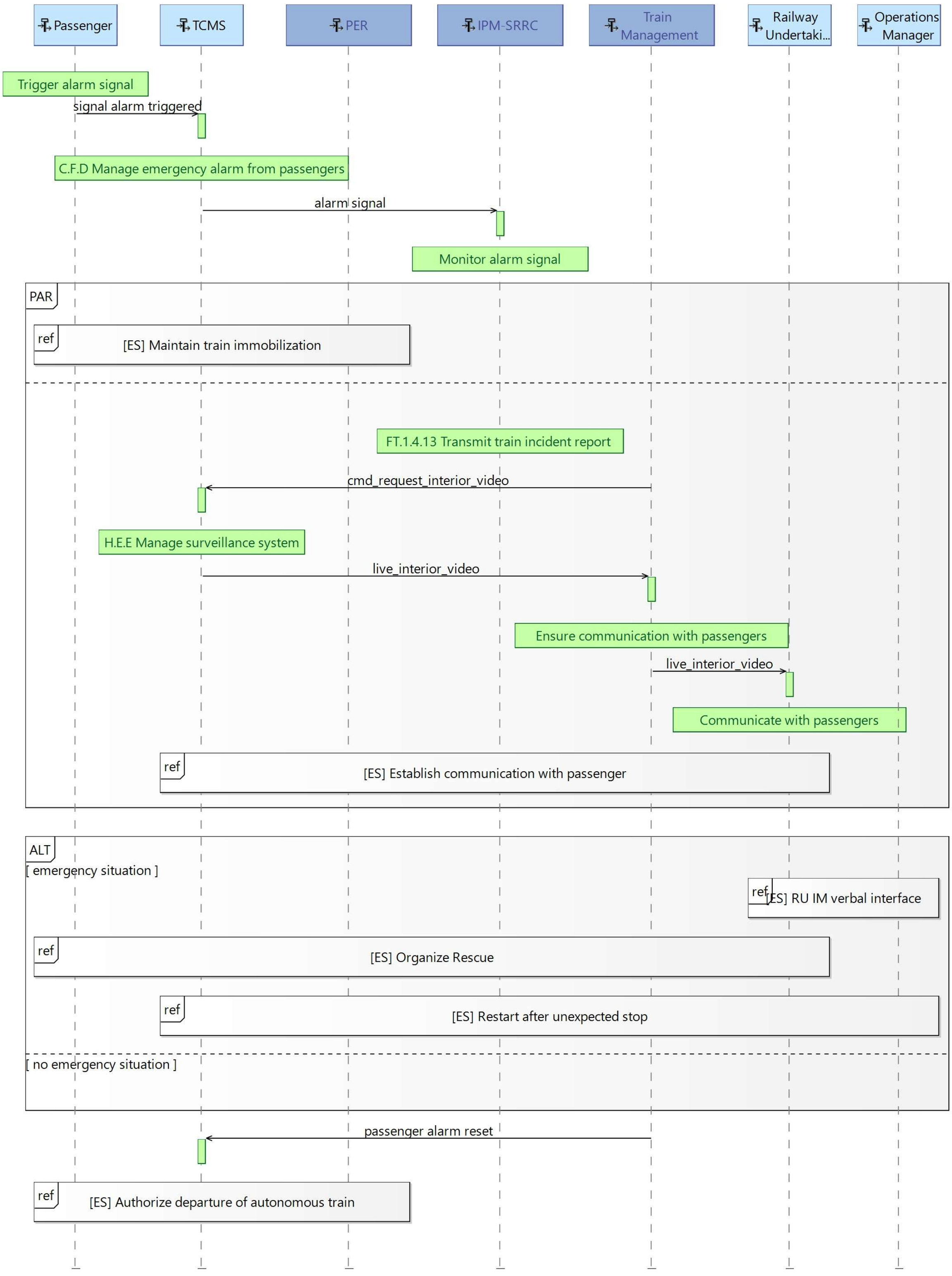



## 12.10.18 Use of Call for Help Button in station

This Use Case details the actions to be taken in case of Call for Help Button triggered by passengers in station.

Description

Tthe Call for Help button is not safety related but when triggered in a station, it must lead to train immobilisation. Train management must be informed and will reset the alarm after evaluation through CCTV images and voice communication with passengers.



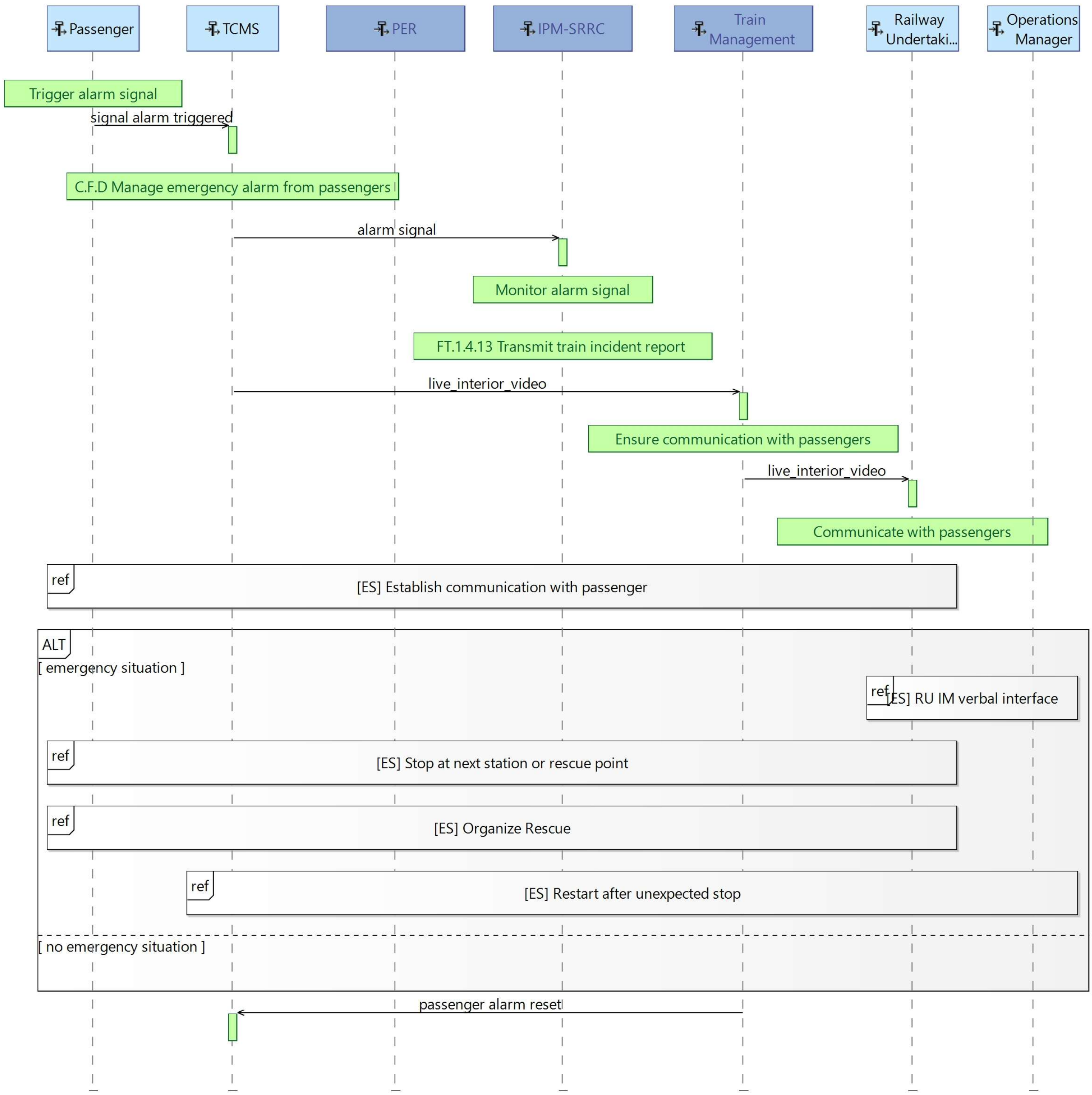
Passenger
TCMS
PER
IPM-SRRC
Train Management
Railway Undertaki...
Operations Manager
Trigger alarm signal
signal alarm triggered
C.F.D Manage emergency alarm from passengers
alarm signal
Monitor alarm signal
PAR
ref
[ES] Maintain train immobilization
FT.1.4.13 Transmit train incident report
cmd_request_interior_video
H.E.E Manage surveillance system
live_interior_video
Ensure communication with passengers
live_interior_video
Communicate with passengers
ref
[ES] Establish communication with passenger
ALT
[ emergency situation ]
ref
[ES] RU IM verbal interface
ref
[ES] Organize Rescue
ref
[ES] Restart after unexpected stop
[ no emergency situation ]
passenger alarm reset
ref
[ES] Authorize departure of autonomous train

## 12.10.19 Use of Call for Help Button during train run

This Use Case details the actions to be taken in case of Call for Help Button triggered by passengers during train run.

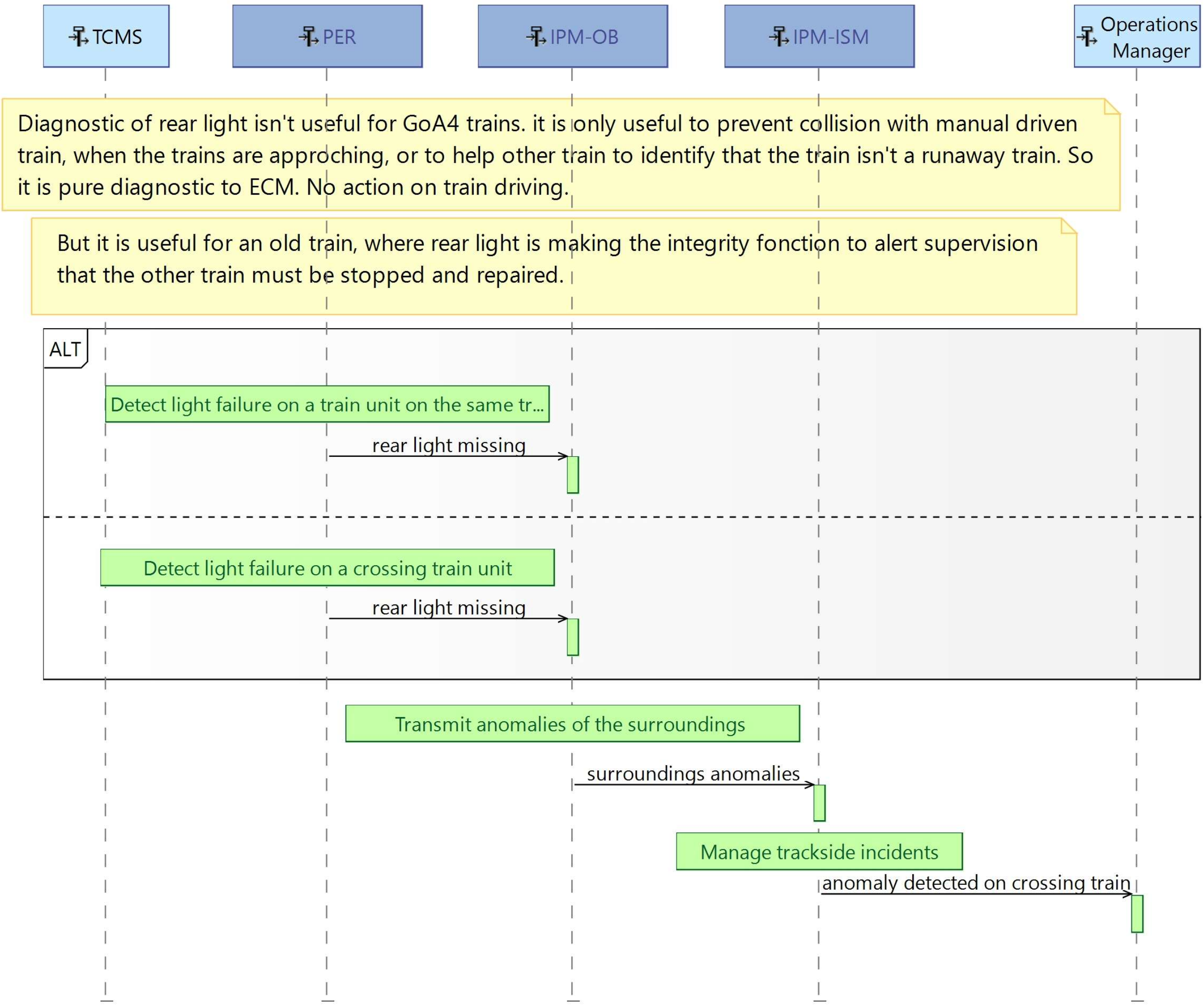
<u>Description</u>

The Call for Help button is not safety related and when triggered during train run, IPM will not stop the train. Train management must be informed and will reset the alarm after evaluation through CCTV images and voice communication with passengers.



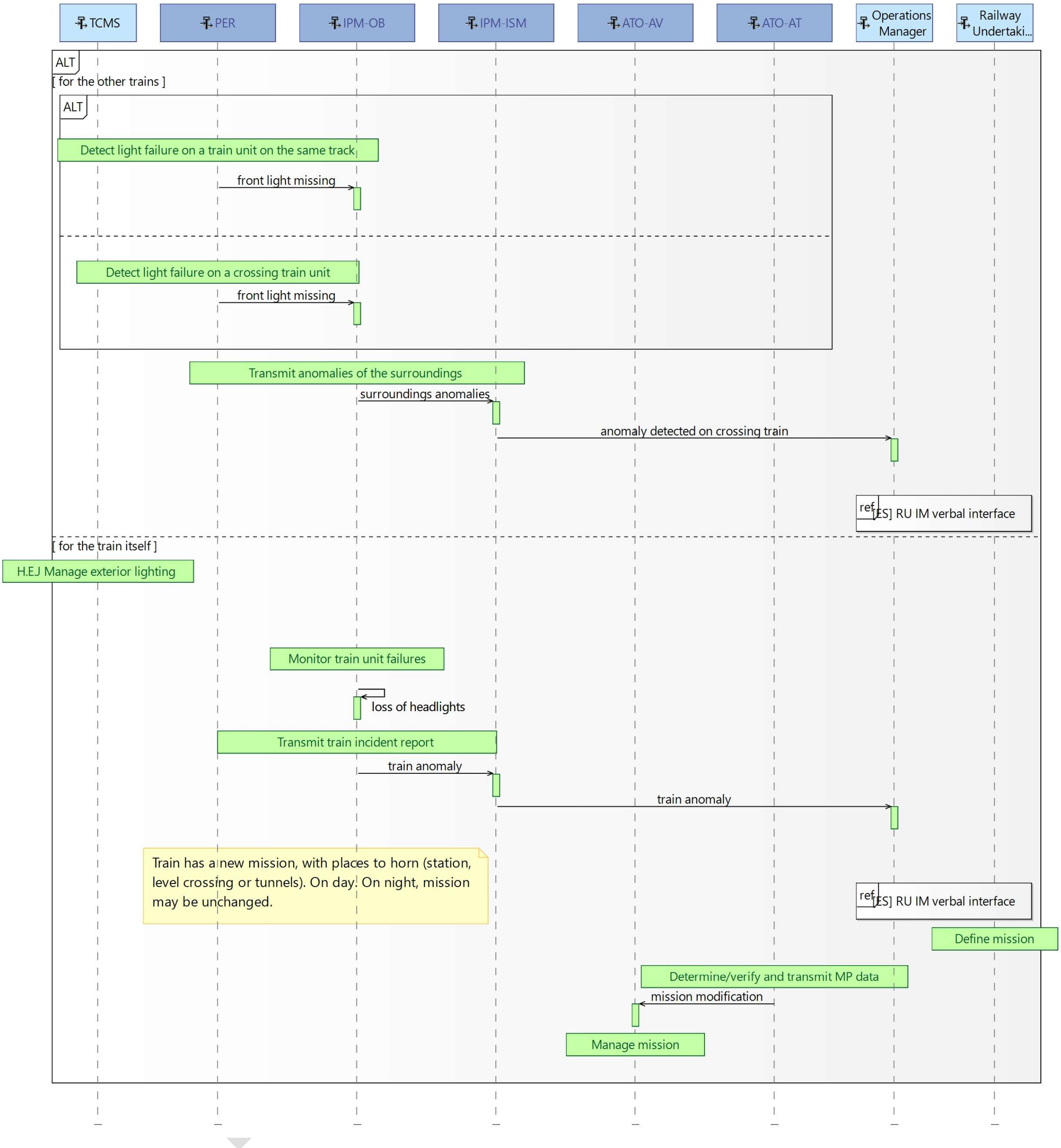
### 12.10.20 Rear Light Default

This Use Case details the actions to be taken in case of rear light missing on a neighbour train.




### 12.10.21 Front light Default

This Use Case details the actions to be taken in case of front light default on the train or a neighbour train.

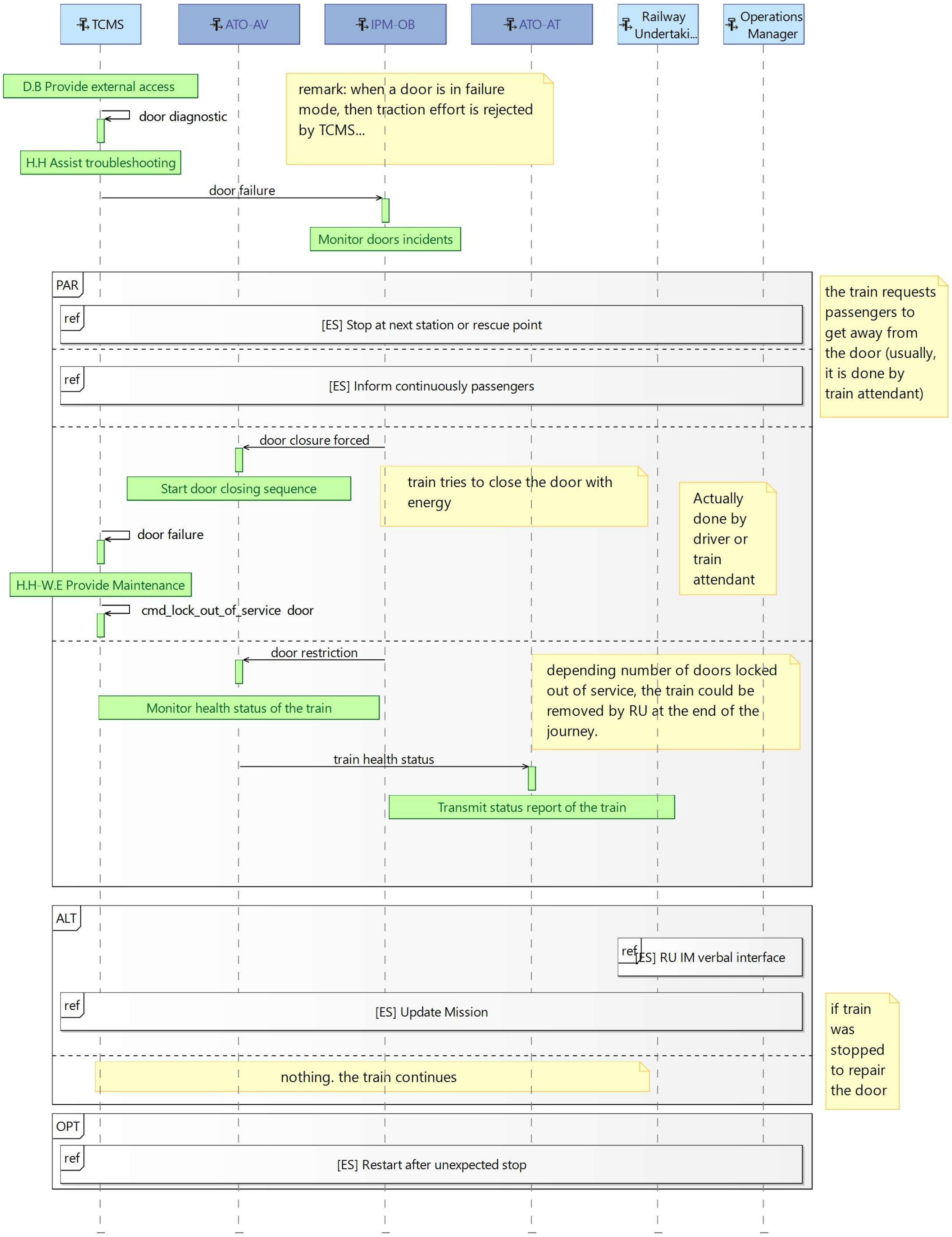



### 12.10.22 Door failure during train run

This Use Case details the actions to be taken in case a door failure is detected during train run.

Description

A door failure will modify the flow of passengers during embarkment/disembarkment. A door restriction can be communicated through train health status in order to increase the dwell time.



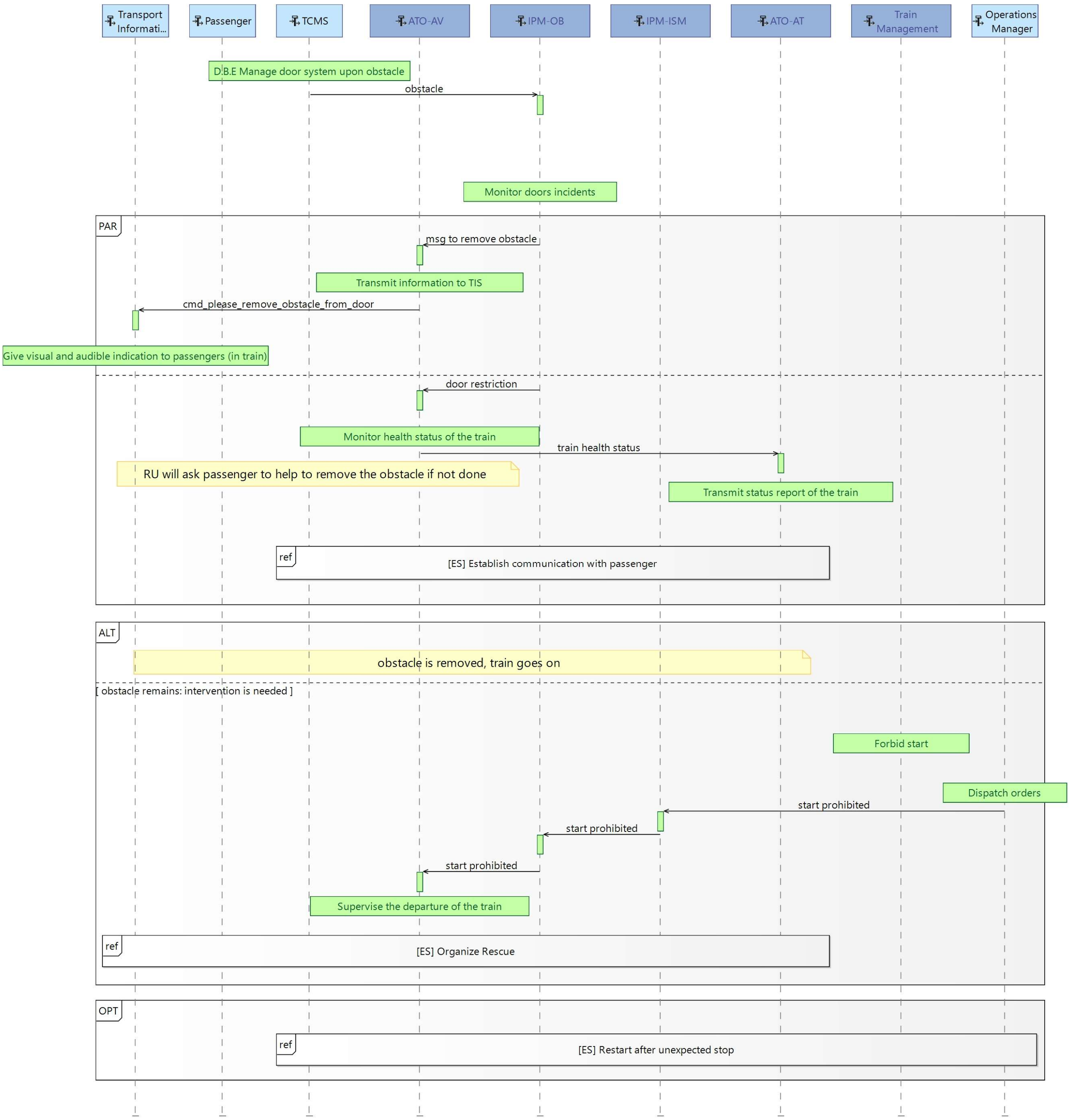

### 12.10.23 Obstacle when door is closing

This Use Case details the actions to be taken in case an obstacle is detected during door closing.

Description

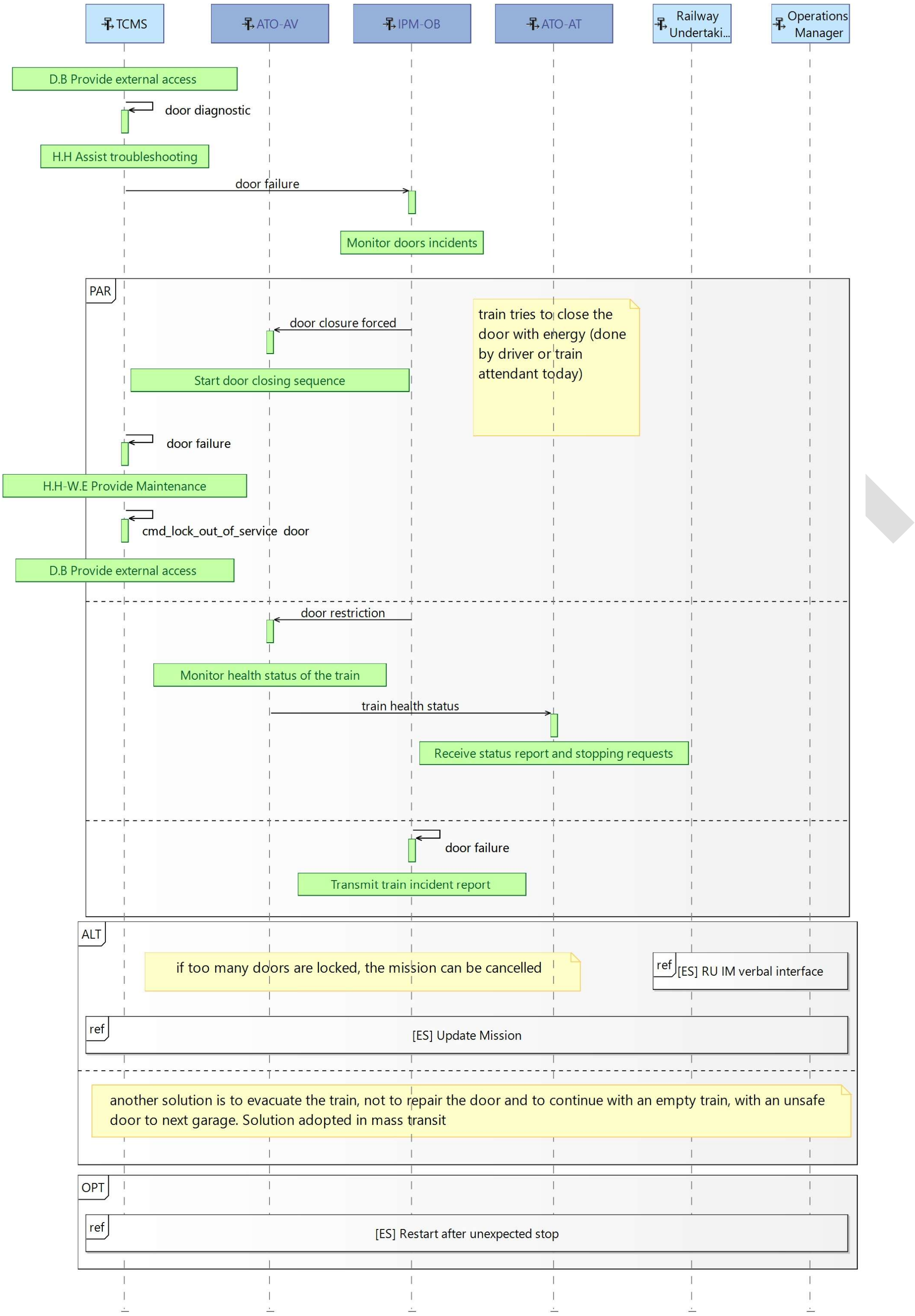
In case of incident, IM can hold a train at platform through JP (variable Q_Train_Hold) but the closing of the doors is the responsibility of RU. Closing will be forced by RU when the problem is solved (it could be necessary to request an intervention from staff at platform). No traction is possible when a door is open (TCMS function).

Either ATO is in GoA3 and the train attendant is responsible of the closing of the doors or ATO is in GoA4 and triggers the door closing using information from Perception and door system. If a key is inserted in the door system by RU staff like today, the closing process is delayed until the key is released.




### 12.10.24 Doors failure during closing sequence

This Use Case details the actions to be taken in case a door failure is detected during door closing.




### 12.10.25 Broken window

This Use Case details the actions to be taken in case of broken window.

Description

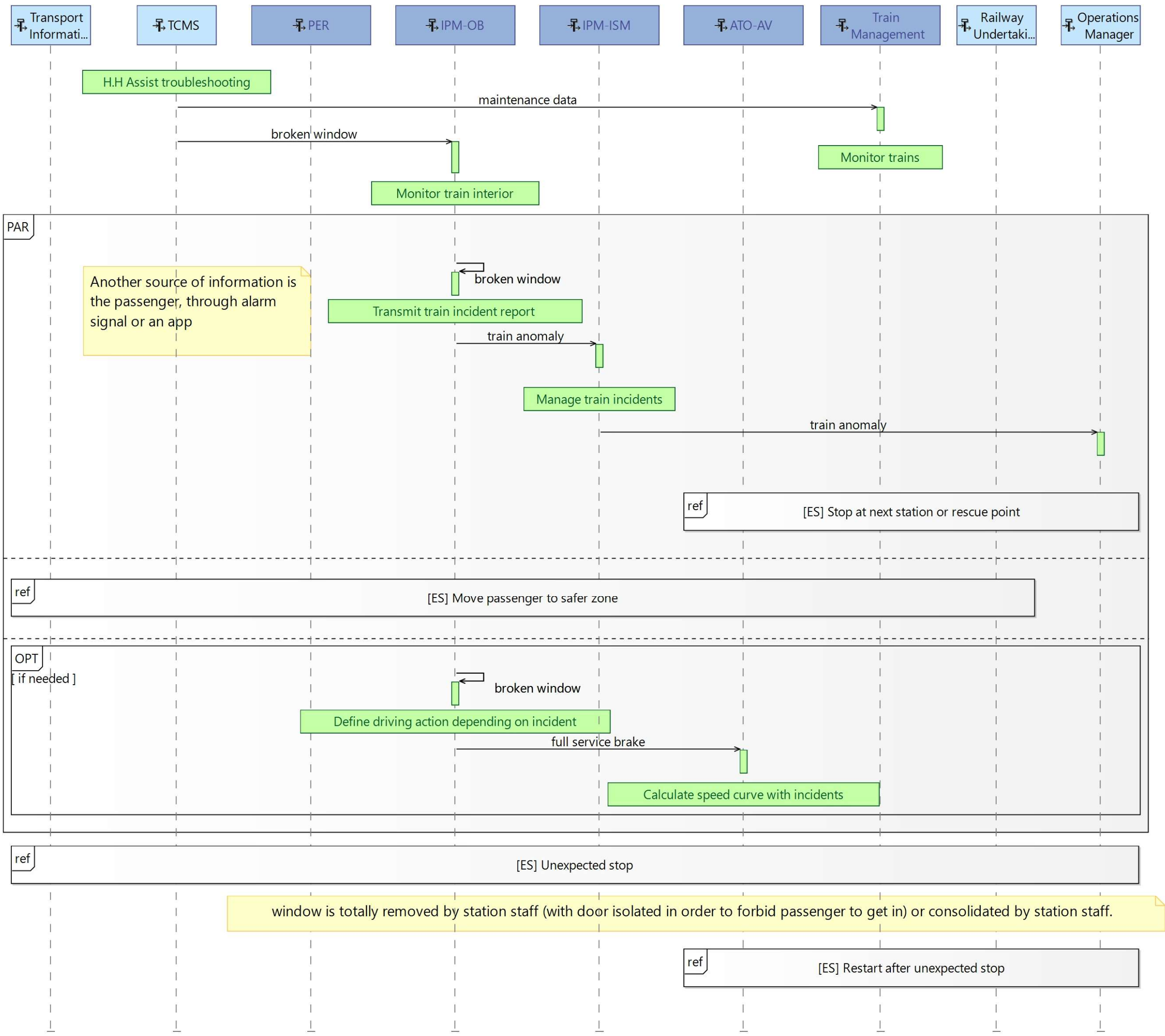
A coach with a broken window must be evacuated. The evacuation can be done during train run, it is not necessary to stop the train.

Train Management must be informed for maintenance and for the locking of related coach by remote control. Information to TIS is also required.

Traffic Management should also be informed through IPM. The coach is no more available for embarking passengers and the dwell time could be increased to manage the reduced number of doors.

A continuous supervision of the windows is preferred to the punctual detection that could be offered by a trackside device. It is not expected that CCTV images will cover all the windows of a train. A monitoring of train interior pressure offers a simple solution that could be managed at coach level.

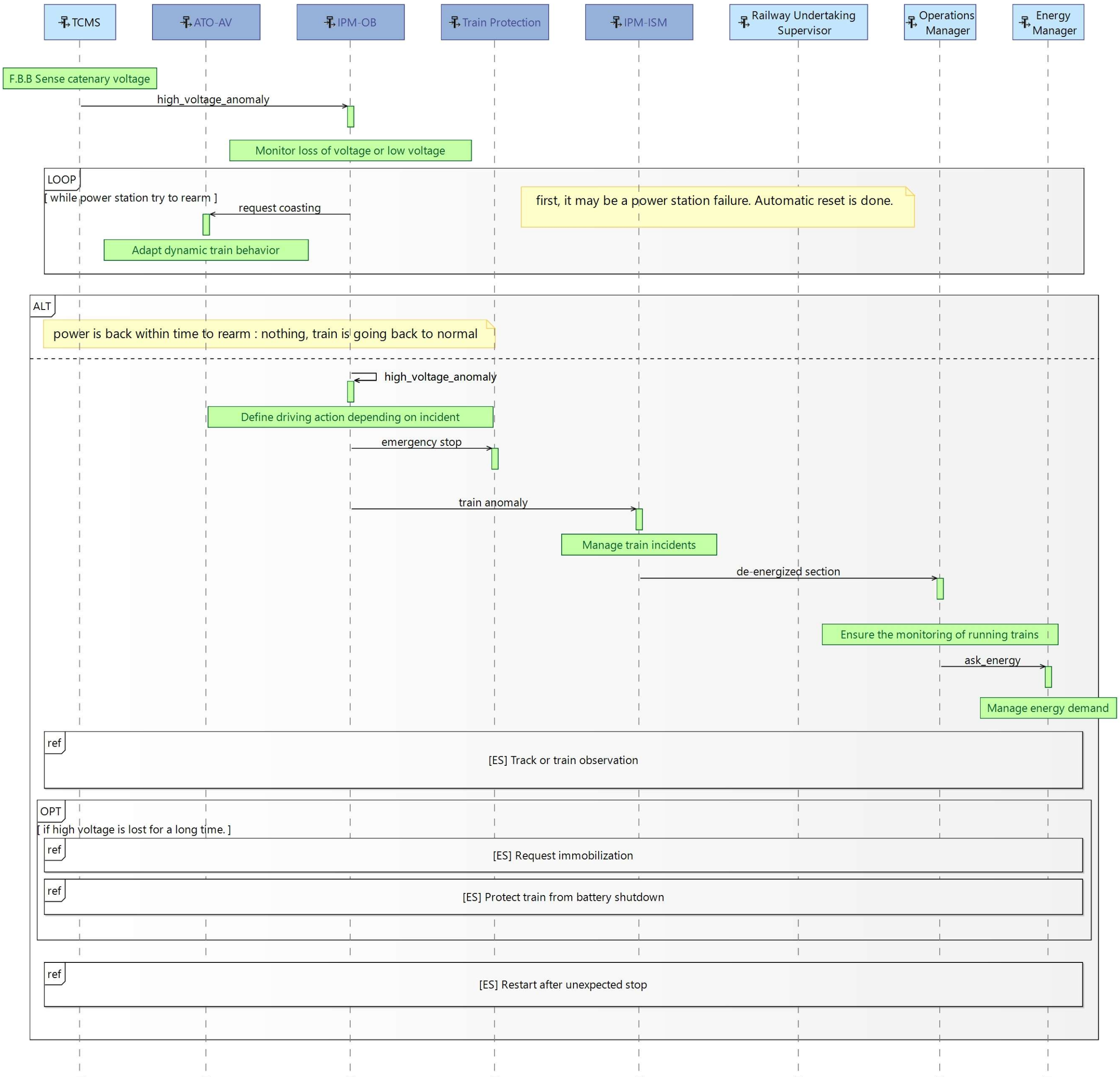
Broken window is a train failure (like a climate failure) and must be managed by TCMS (related sensor should be part of TCMS, not of PER component). SIL to be determined.




## 12.11 React to track related incidents

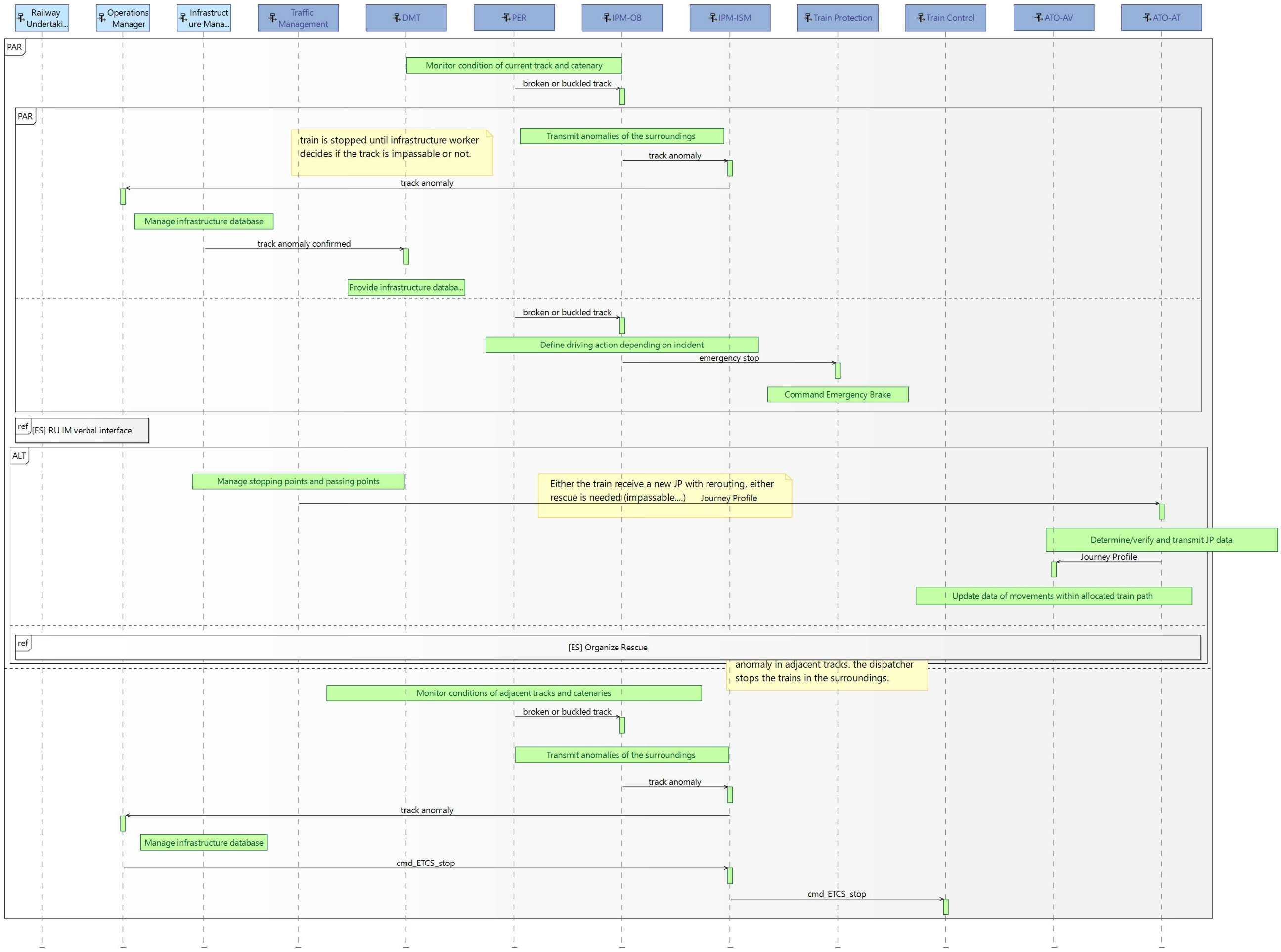
### 12.11.1 Sudden Lack of Catenary Voltage

This Use Case details the actions to be taken in case of loss of voltage or loss voltage.



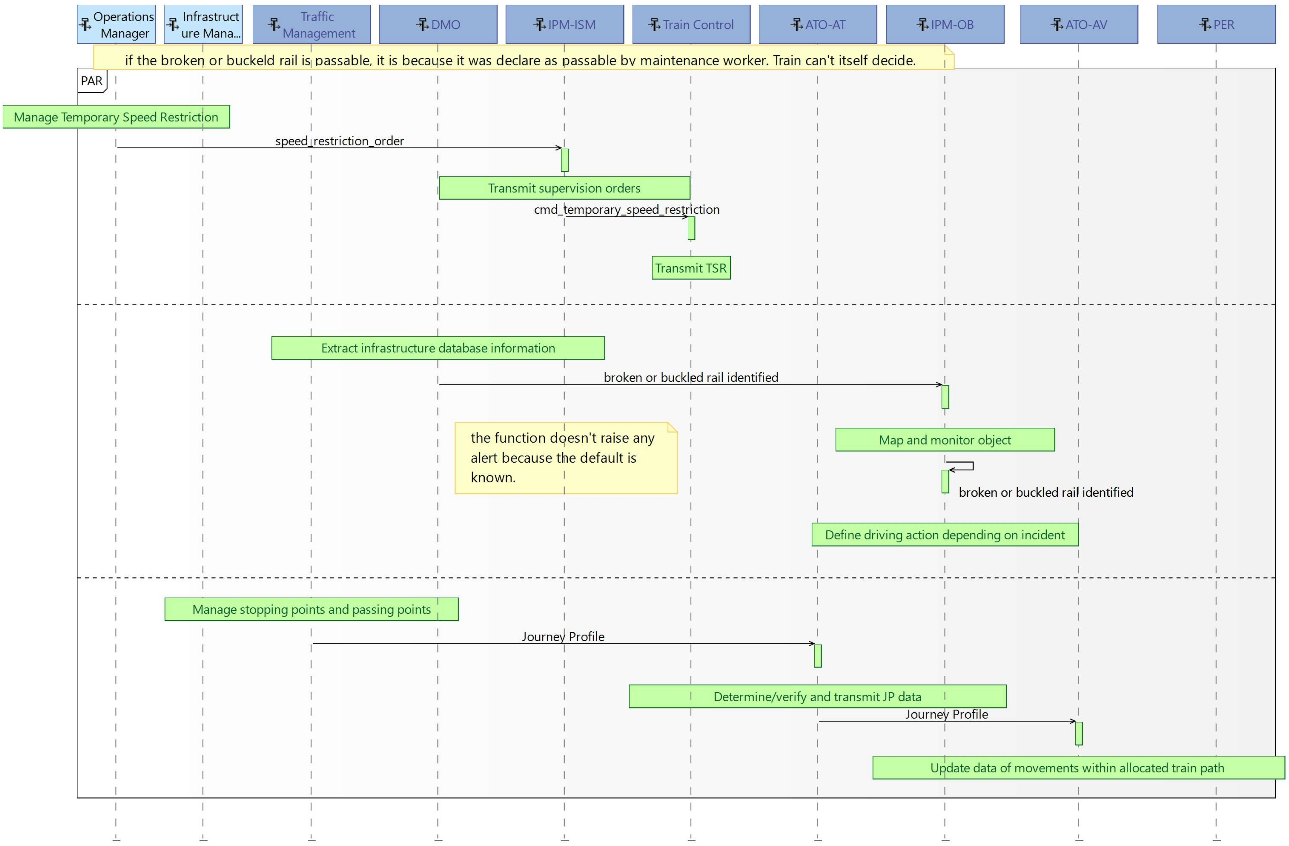

### 12.11.2 Impassable Broken or Buckled Rail

This Use Case details the actions to be taken in case of blocking default detected on the track.




### 12.11.3 Broken or Buckled Rail passable with reduced speed

This Use Case details the actions to be taken in case of default detected on the track.




### 12.11.4 Impassable flooding

This Use Case details the actions to be taken in case of important flooding detected on the track.

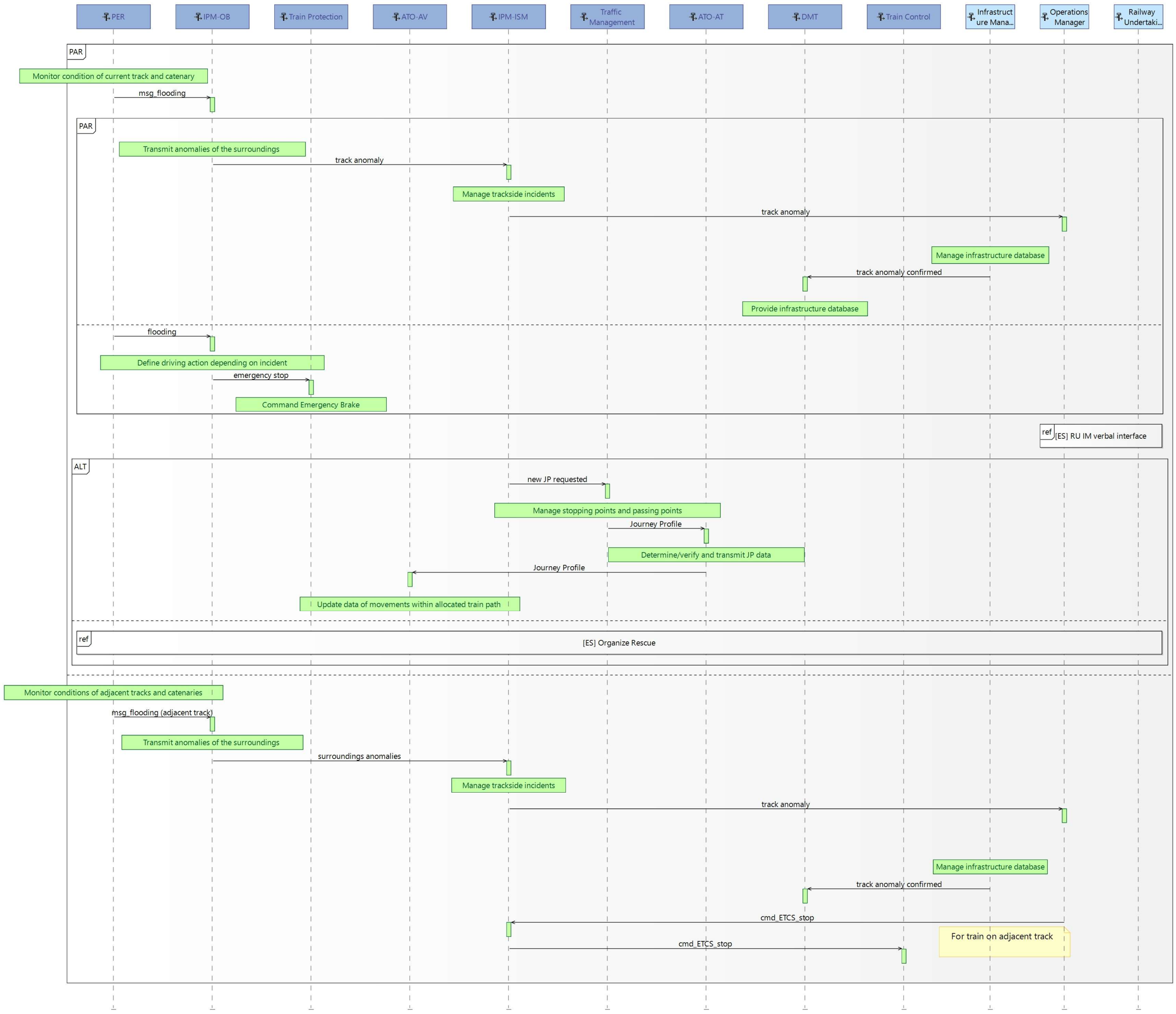
<u>Description</u>

Flooding has an impact on safety, it can bring mud on the track and modify track circuit characteristics.

Flooding on current track must lead to EB application. When detected on an adjacent track, it must be reported to control centre in order to send ES message to the train in approach.

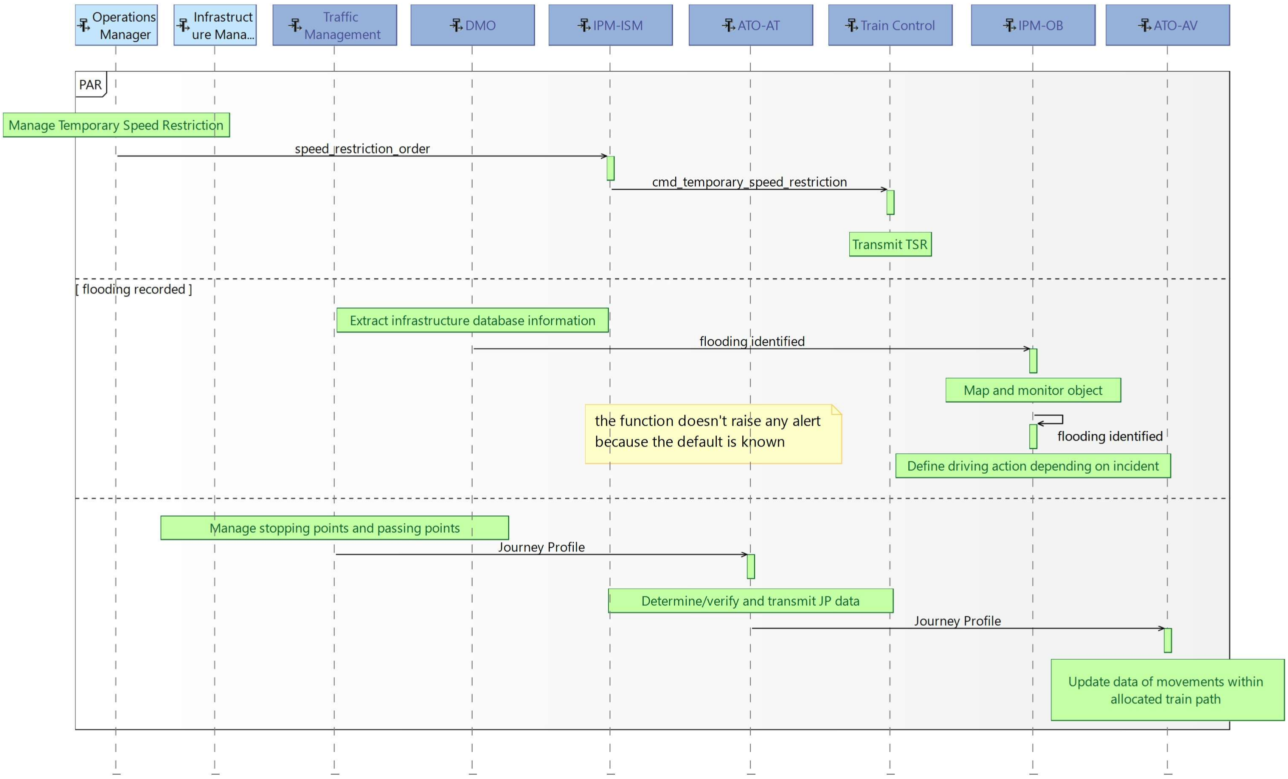
IPM-OB is for the reflexive reaction. Reaction after reporting could be defined country by country. For example, a speed restriction in France or a stop in Germany.

Note: no more track circuits in ETCS L3.



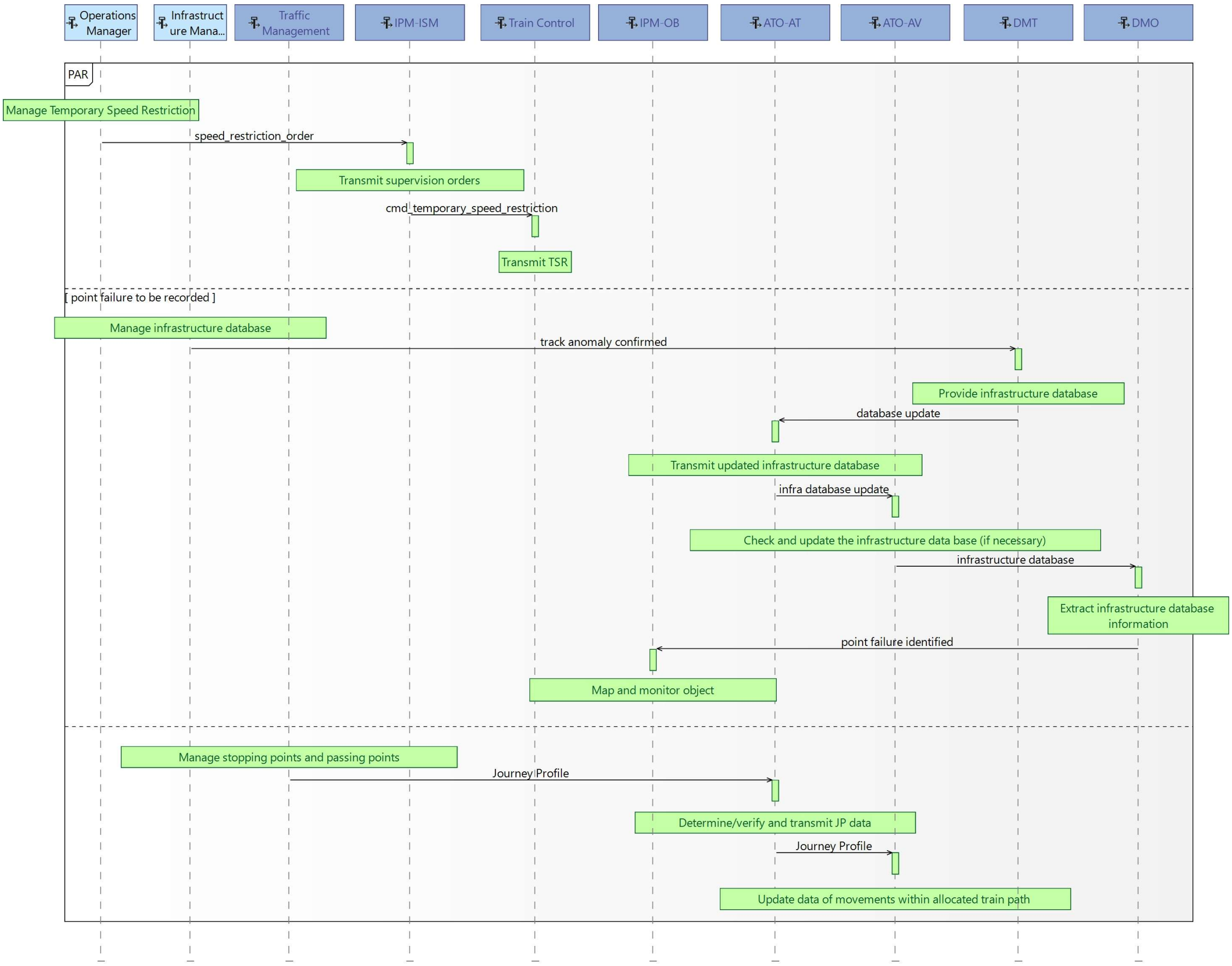

## 12.11.5 Flooding passable with reduced speed

This Use Case details the actions to be taken in case of flooding on the track to be passed at reduced speed.



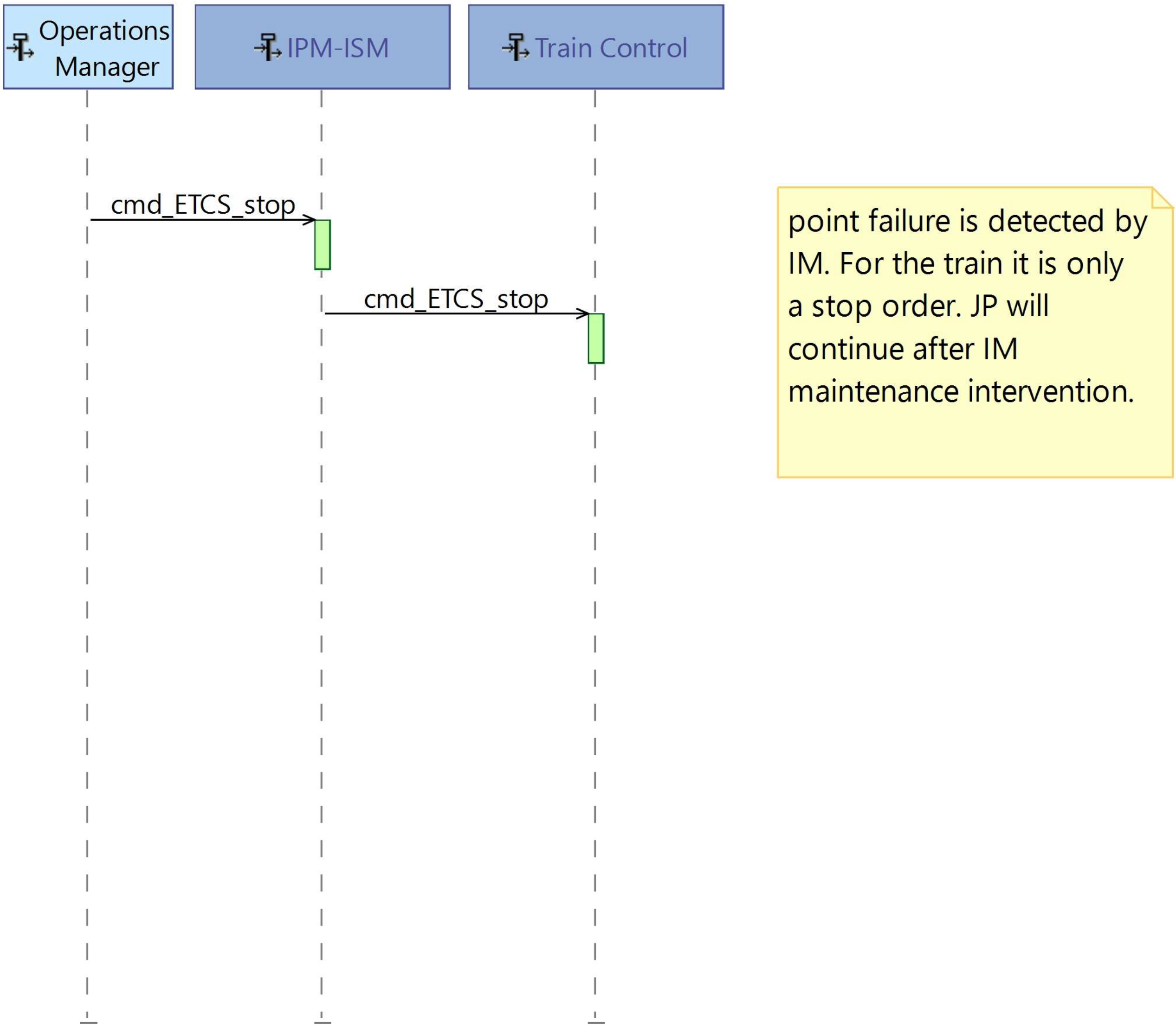

### 12.11.6 Point failure with movement permission

This Use Case details the actions to be taken in case of point failure that can be passed at reduced speed.




### 12.11.7 Point failure without movement permission

This Use Case details the actions to be taken in case of point failure requesting a stop order.

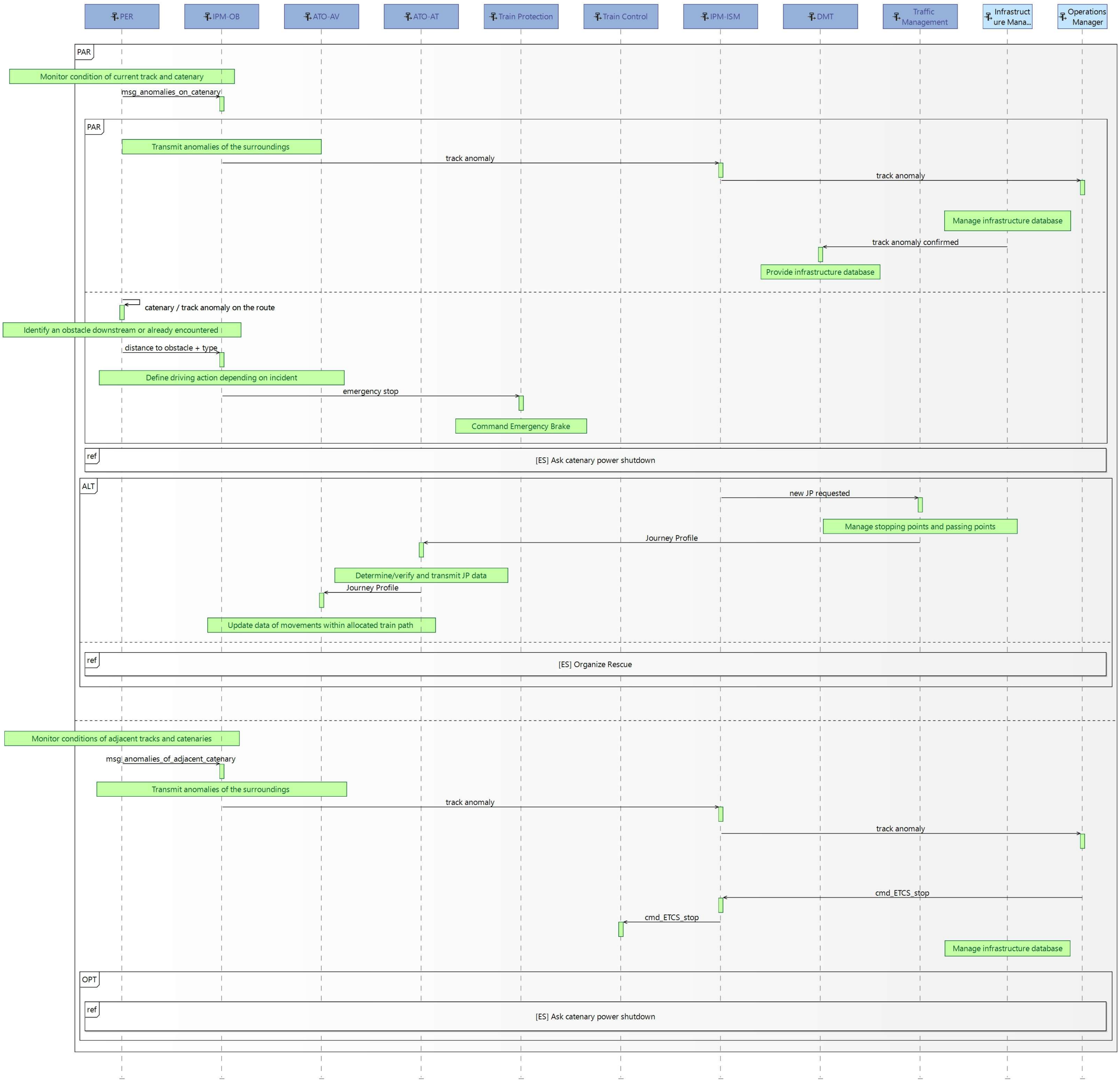



### 12.11.8 Damage to catenary

This Use Case details the actions to be taken in case of damages on catenary.

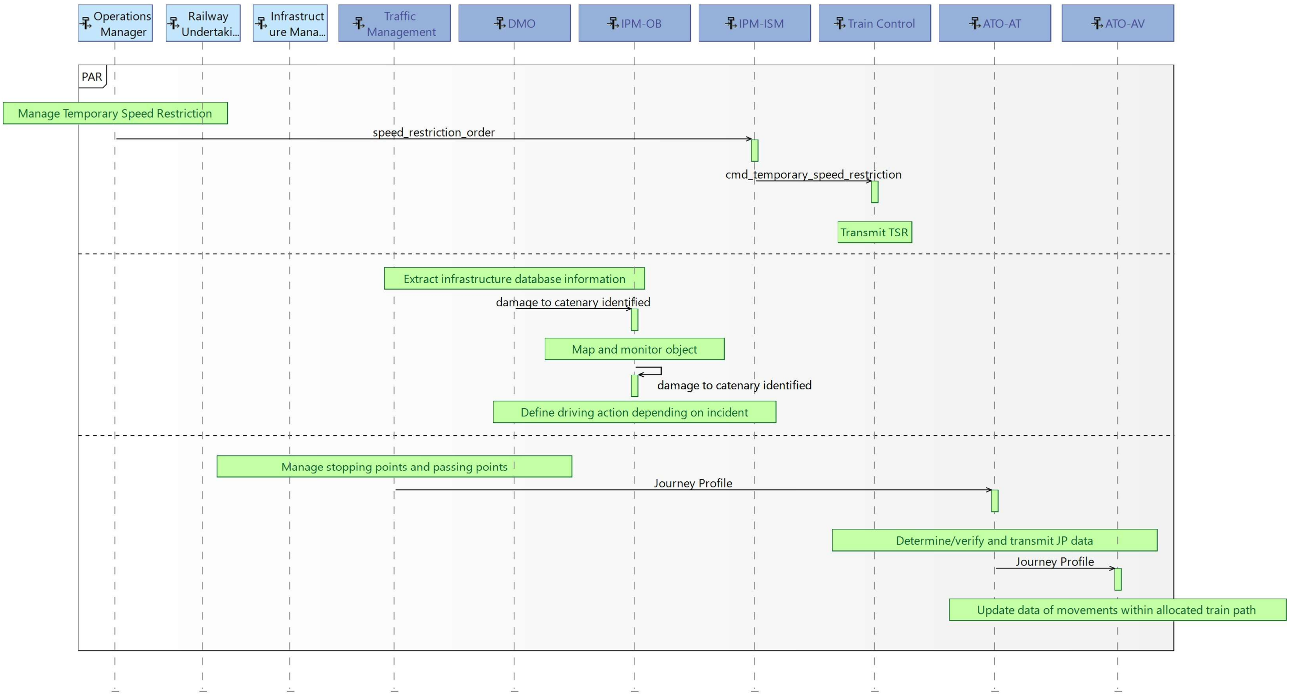
<u>Description</u>

Quality of the catenary is ensured by IM. In case of anomaly detected by PER, IPM-OB must drop the pantograph immediately and inform IM.




### 12.11.9 Damage to catenary passable with reduced speed

This Use Case details the actions to be taken in case of damages on catenary to be passed at reduced speed.



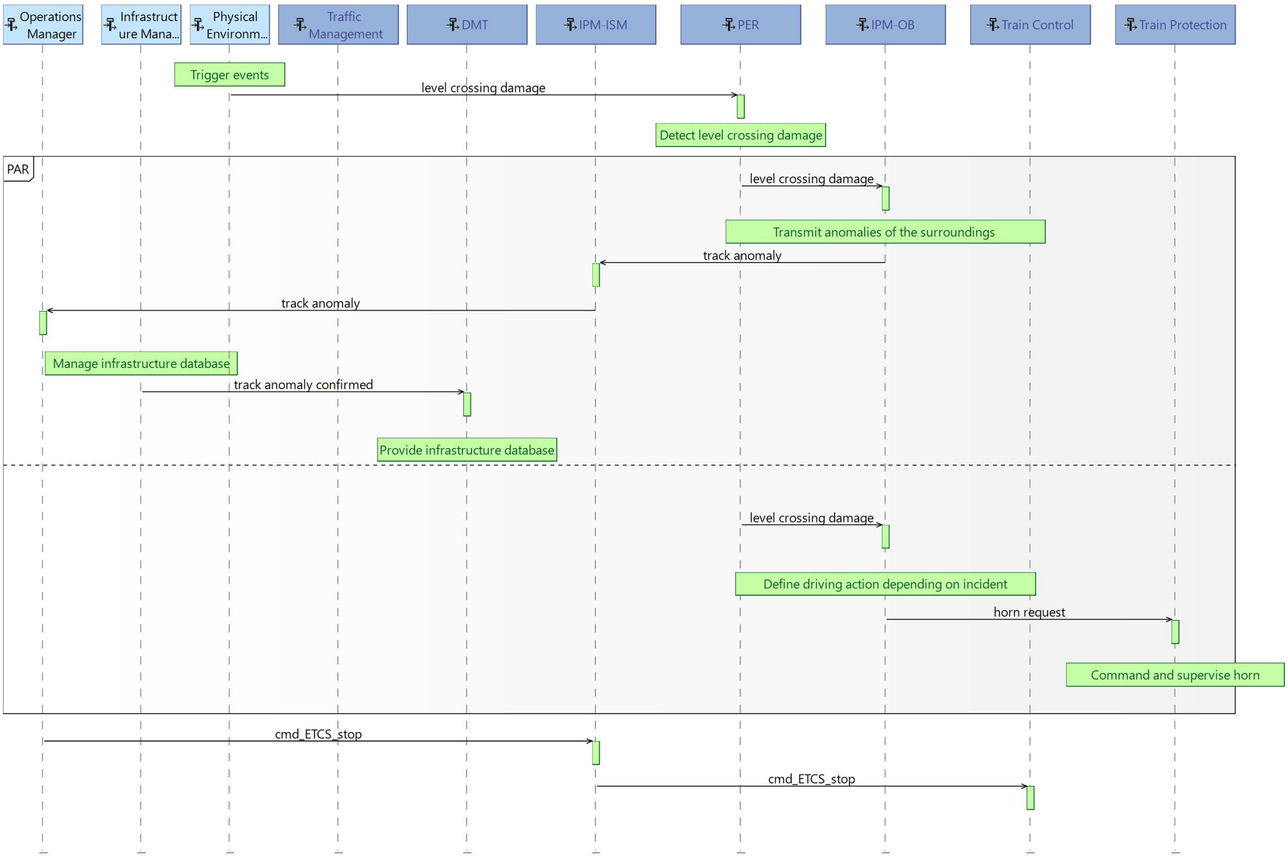

### 12.11.10 Damage to Level Crossing

This Use Case details the actions to be taken in case of damages on level crossing.

<u>Description</u>

A damage can be detected by trackside like in Italy or by the driver like in France. Such anomaly must lead to stop the trains in approach until the problem is solved (a TSR could be enforced for example).

A barrier is designed to be broken if a blocked car wants to escape. In this case, perception can perceive the broken barrier and inform control centre (safety related). Approach is at full speed so the last possible mitigation is to activate the horn.



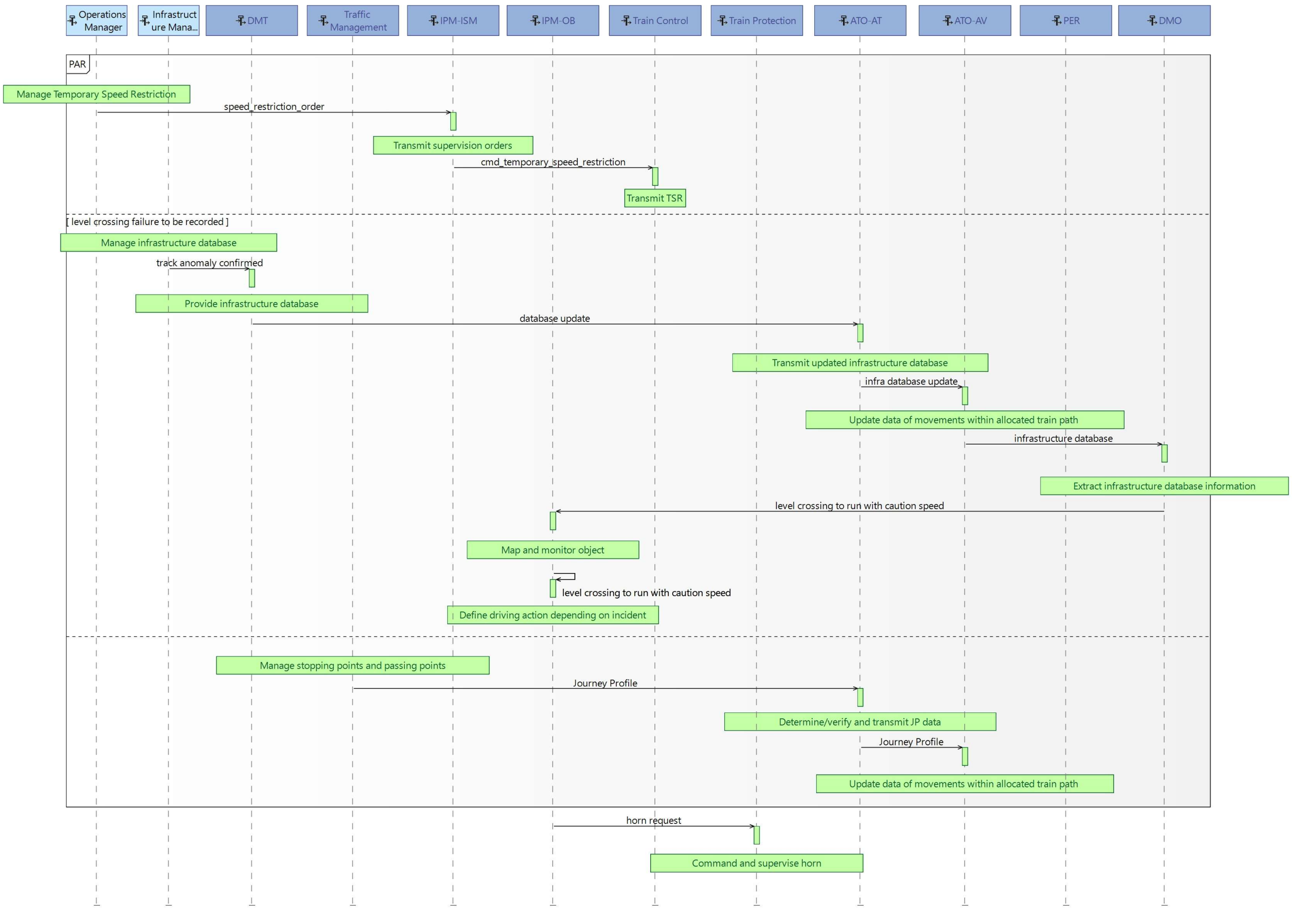

### 12.11.11 Damage to Level Crossing passable with caution speed

This Use Case details the actions to be taken in case of damages on level crossing that can be passed at caution speed.

Description

Damage and associated TSR must be recorded.

Horn is requested before crossing the level crossing.

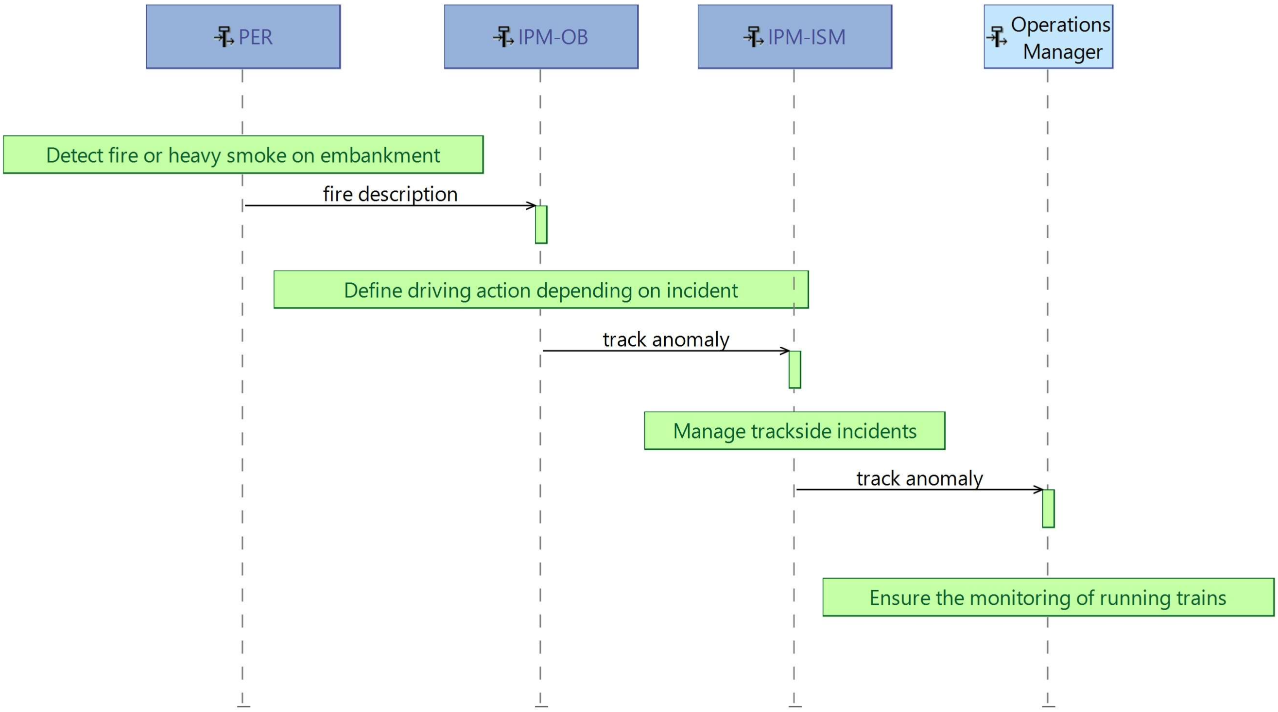



## 12.11.12 Fire on embankment

This Use Case describes the detection and reaction to a fire on embankment.

Description

A fire or heavy smoke on embankment must be reported to IPM trackside in order to decide an appropriated reaction. Stopping the train or moving the train outside the impacted area are possible actions that must be evaluated considering also the weather conditions (a change of wind direction for example).




## 12.12React to passenger related incidents

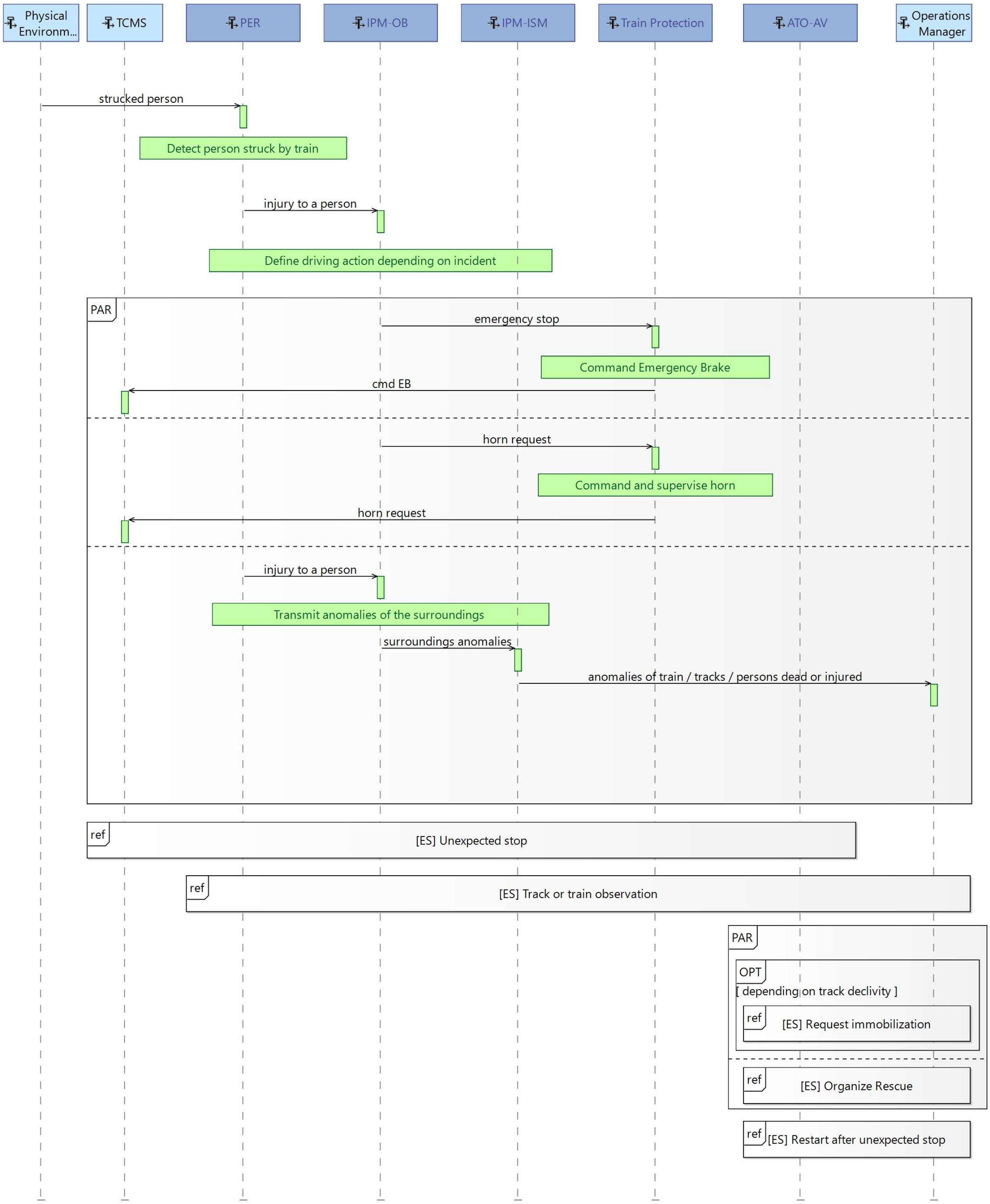
### 12.12.1 Human accident involving injury or death

This Use Case details the actions to be taken in case of human accident.

Description

The discovery of a strucked person must be reported for asking help, the person could be still alive.

The train should be stopped to let the train attendant help for example.



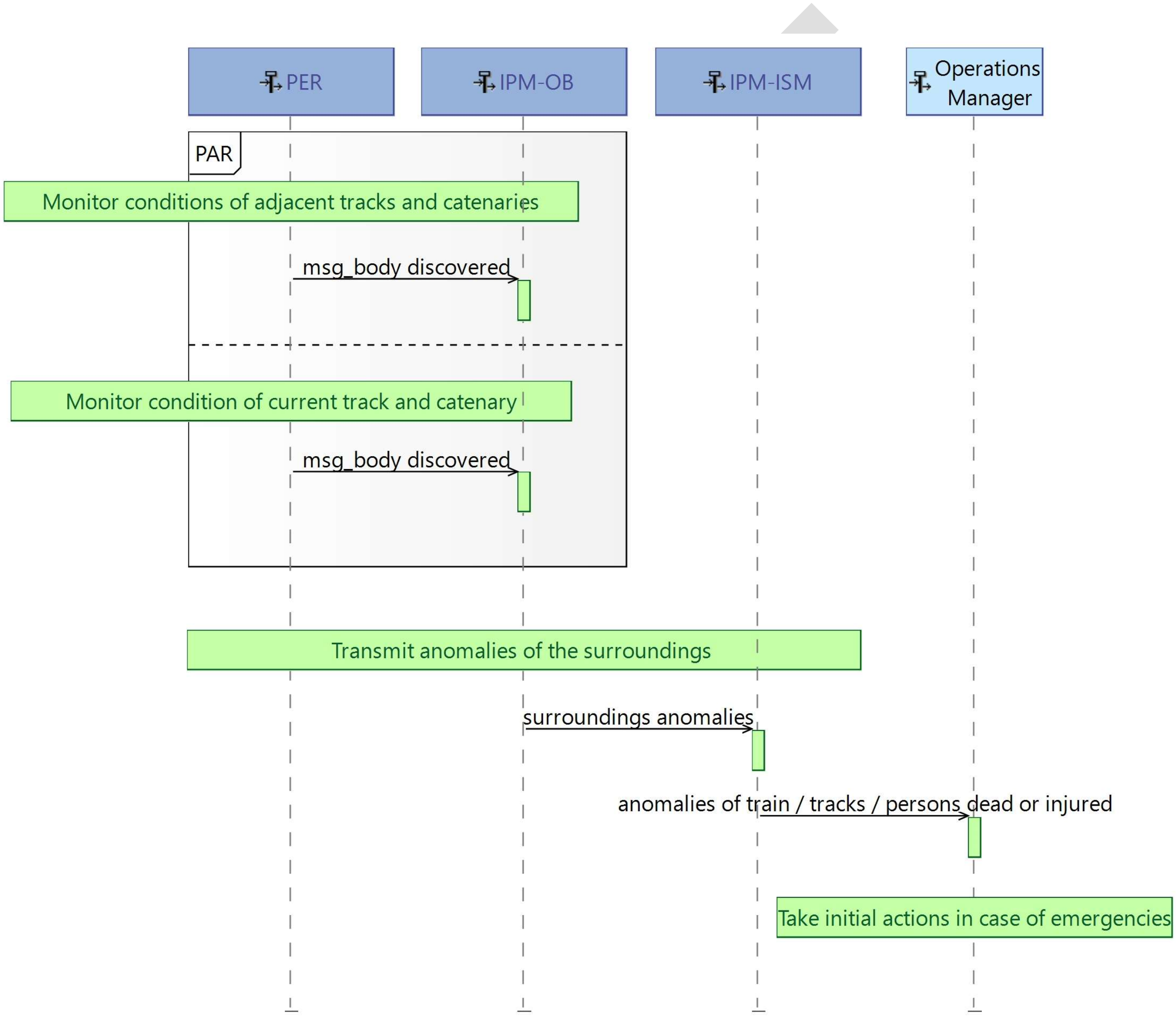
Physical Environm...
TCMS
PER
IPM-OB
IPM-ISM
Train Protection
ATO-AV
Operations Manager
strucked person
Detect person struck by train
injury to a person
Define driving action depending on incident
PAR
emergency stop
Command Emergency Brake
cmd EB
horn request
Command and supervise horn
horn request
injury to a person
Transmit anomalies of the surroundings
surroundings anomalies
anomalies of train / tracks / persons dead or injured
ref
[ES] Unexpected stop
ref
[ES] Track or train observation
PAR
OPT
[ depending on track declivity ]
ref
[ES] Request immobilization
ref
[ES] Organize Rescue
ref
[ES] Restart after unexpected stop

### 12.12.2 Human accident involving injury or death - Body discovered

This Use Case details the actions to be taken in case a human body is detected in the vicinity of the train.

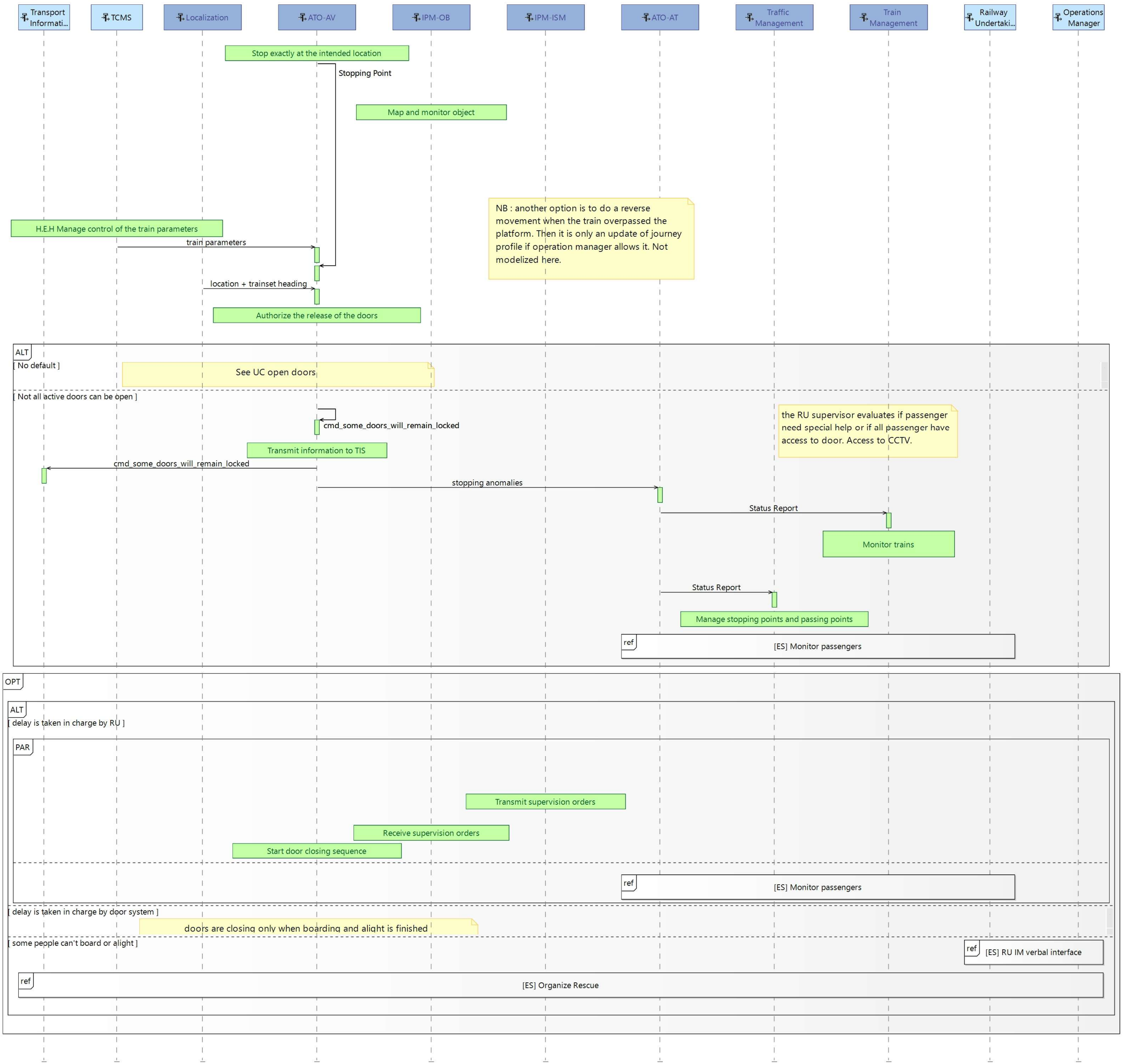
Description

In this case, a body is detected near the track but it is not related to a possible hit by the train. The train does not stop but an alarm is sent to the dispatcher.




### 12.12.3 Passenger train only stops partially at a platform

This Use Case details the actions to be taken in case of doors not aligned with the platform.

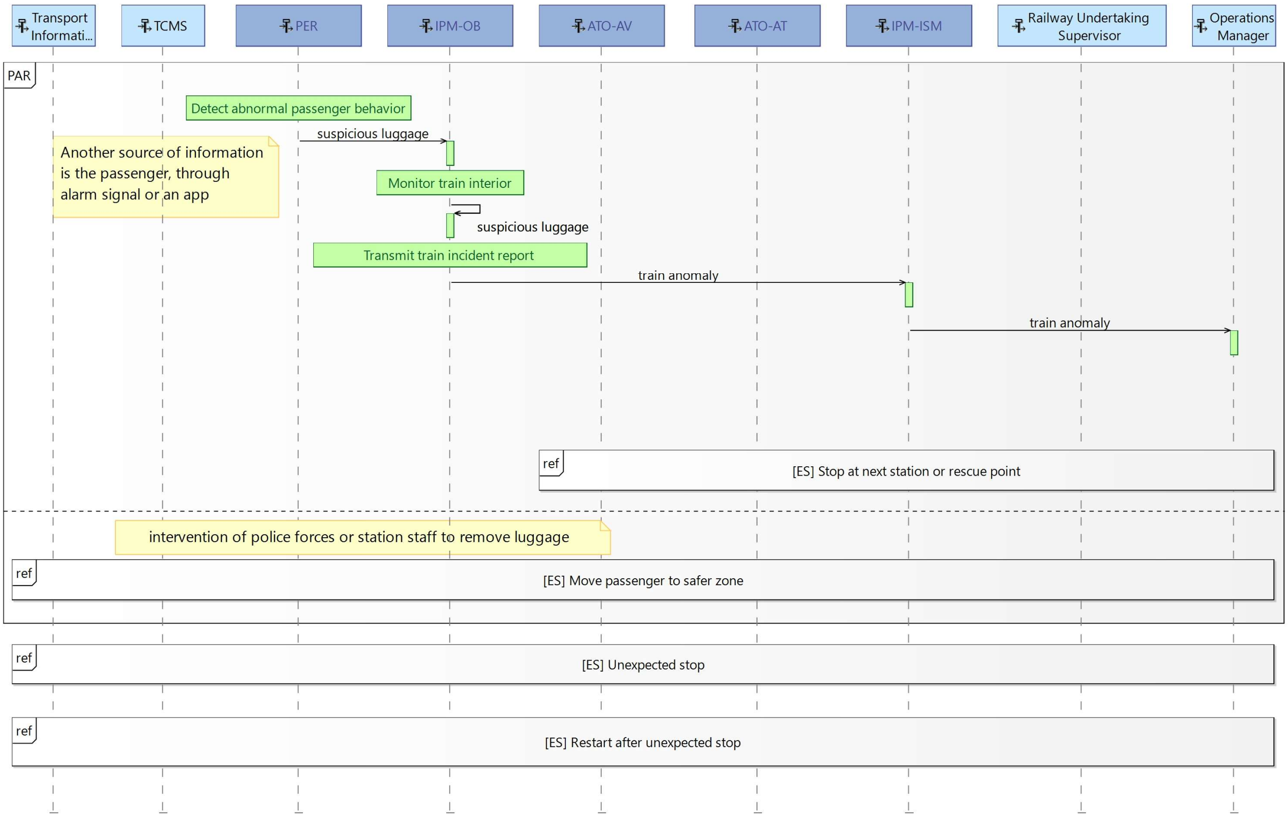



### 12.12.4 Abandoned / Suspicious luggage on train

This Use Case details the actions to be taken in case of suspicious luggage detected onboard.

<u>Description</u>

A suspicious luggage must be reported to Train Management for analysis and validation. IPM trackside must also be informed in order to prepare a possible intervention at next station when confirmed by RU.

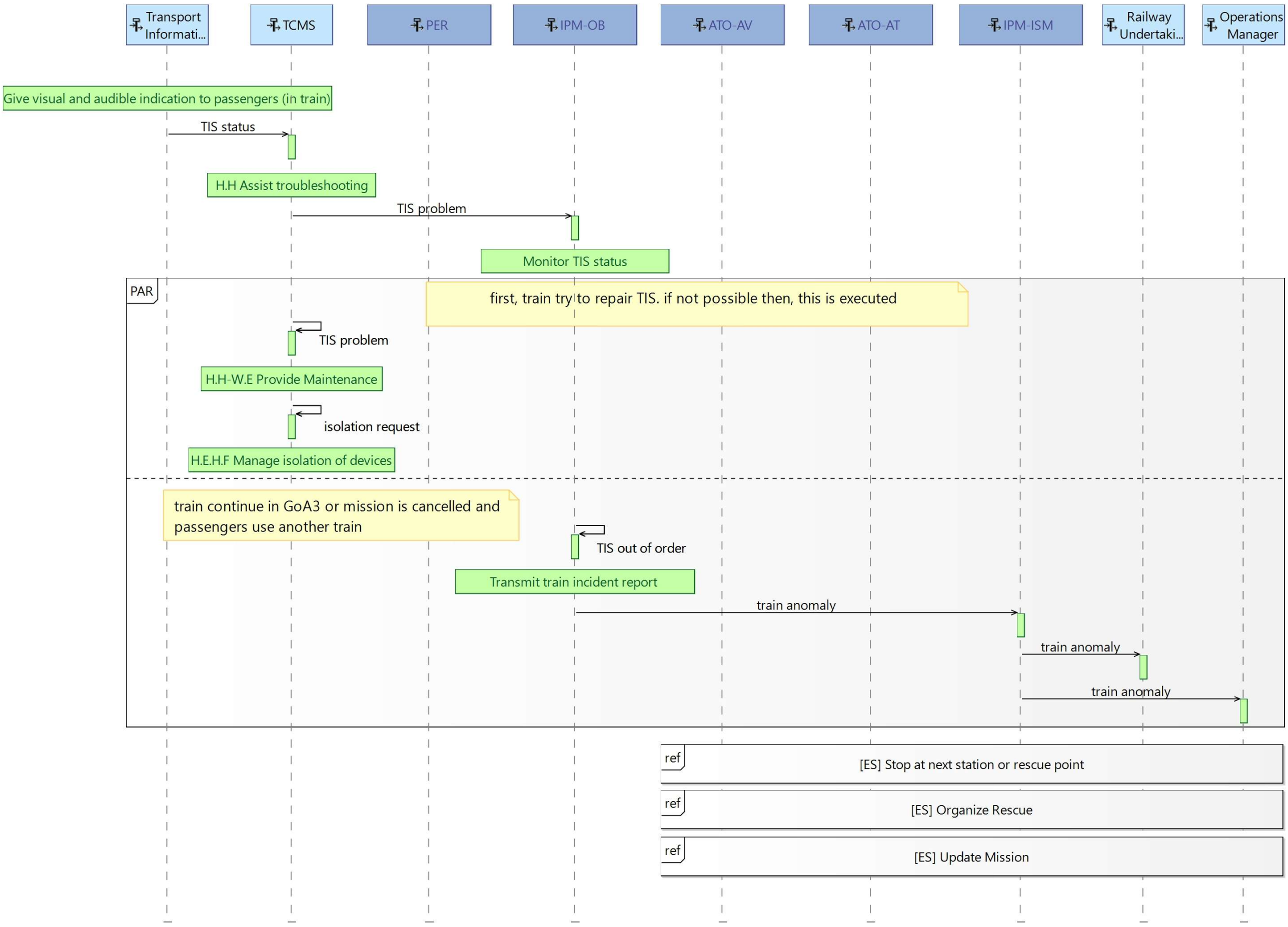



### 12.12.5 Passenger information system default

This Use Case details the actions to be taken in case of TIS default.

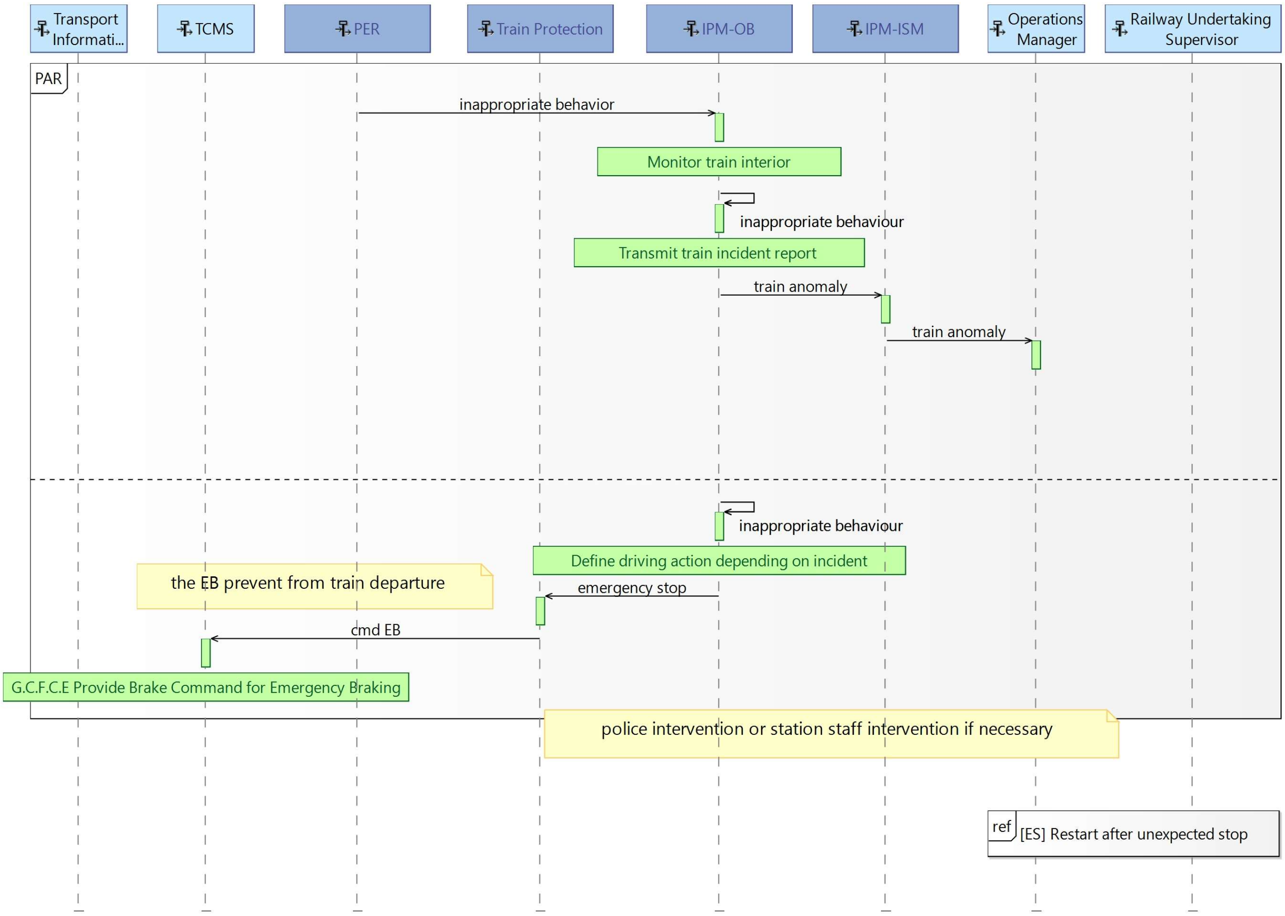
Description

Journey information should be standardised (the type, not the format). IPM must be informed in case of default because a TIS failure can interrupt a mission (TIS redundancy is provided to increase availability).



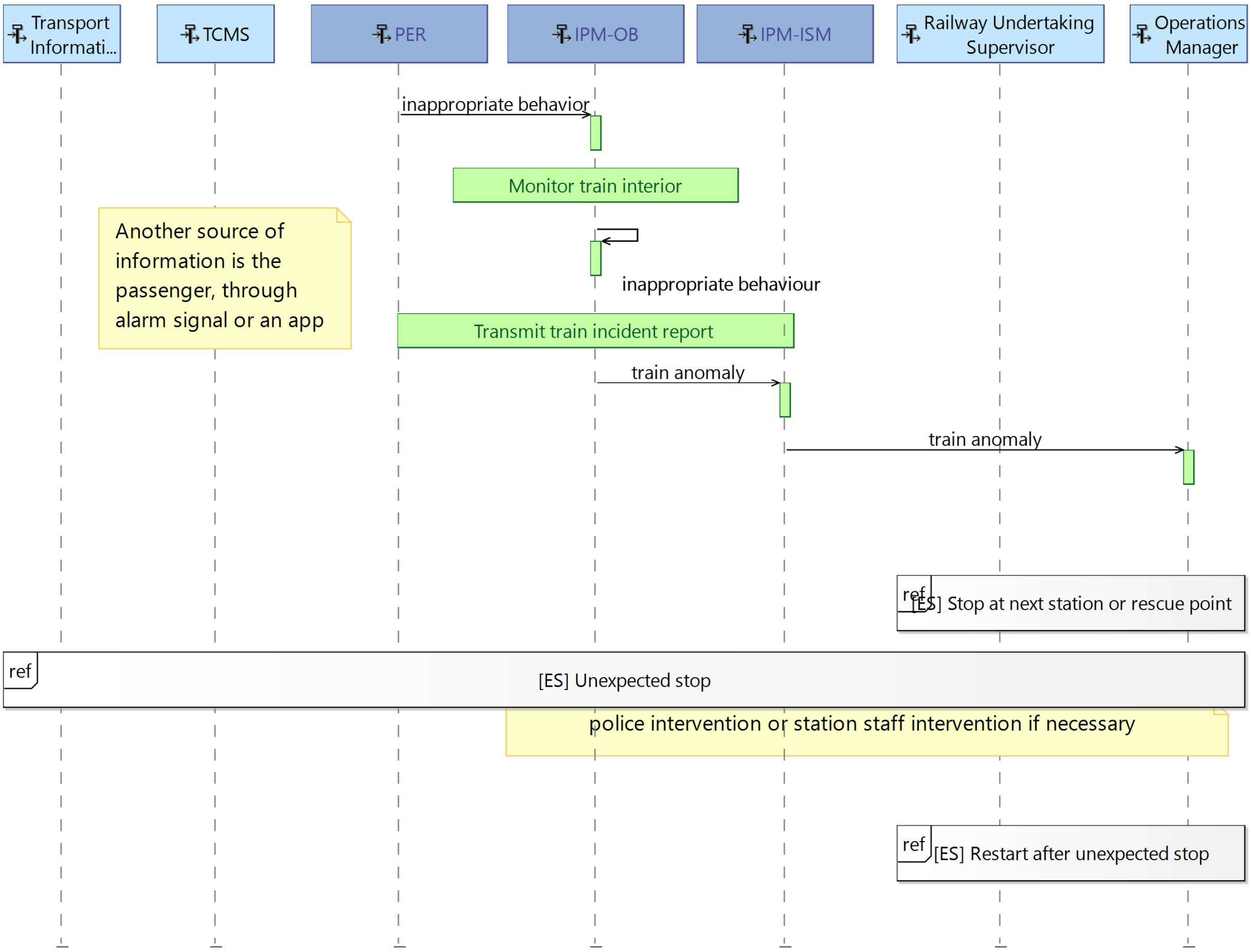

### 12.12.6 Inappropriate behaviour in train in station

This Use Case details the actions to be taken in case of passenger abnormal behaviour in station.




### 12.12.7 Inappropriate behaviour in train during operation

This Use Case details the actions to be taken in case of passenger abnormal behaviour while running.




## 12.13 System failure scenarios

### 12.13.1 Remote Driving

This Use Case details the rescue tool used in case of system failure.

Description

The remote driving is used in GoA34 to manage some degraded situations where the train is still able to move. The train is stopped after a failure of GoA34 system and there is no driver available to permit a switch to GoA0, GoA1 or GoA2.

The remote driving must rely on a channel independent from GoA34 system for covering all degraded situations including the failure of Perception. The remote driving should be kept as simple as possible with a single procedure for operating the train in order to avoid a complex training of the remote driver. Several remote driving modes depending on the failures of GoA34 components should be too complex.

A solution based on a direct connection between RU and TCMS (ground channel) is therefore proposed. RU must be able to activate a TCMS remote control mode through this channel to bypass the GoA34 commands and accept the commands of a remote driver.

In some degraded modes, ETCS remains operational and protects the train movement during remote control (SR movement with limited speed). If ETCS is available, it will prevent backward movement except if it is in SH or RV mode.

In case of ETCS failure, remote driving should be a pure GoA0 movement performed under operational procedures after ETCS isolation through C48 (safety level to be determined).

The remote driver should run at low speed because perception is limited to rough track images and the feedback loop on traction and brakes introduces delays. A more complex perception is not expected to keep a simple solution at reasonable price (detection of vibrations or abnormal noises are not expected for example). The maximum speed should be configurable and controlled by TCMS. This speed must also be supervised by ETCS if available (train related speed restriction). If ETCS is available, it will prevent backward movement except if it is in SH or RV mode.

The number of commands performed by the remote driver while running must include at least the actions on the traction (forward/backward) and brakes. The implementation of automatic actions like pantograph lowering or horn activation in ETCS is preferred however it should also be possible to provide related ETCS-DMI information for a manual action. The tasks of a remote driver will depend on the train type, they will be quite different between an electrical high speed train and a diesel freight loco for example.

The remote control provides a good example of interchangeability. Even in the case of a national train not concerned by interoperability, a standard is required to ensure that the remote control interface remains the same with different trains.

The remote driving is mainly foreseen to drive the train until a stopping point where a driver is available to continue in a lower GoA level or where maintenance is possible without affecting traffic operation. It is not foreseen to exit a depot or for running a long distance however it must include at least the door opening command for disembarking passengers under the supervision of ETCS if necessary. The closing of the doors will not be possible without a lateral view.

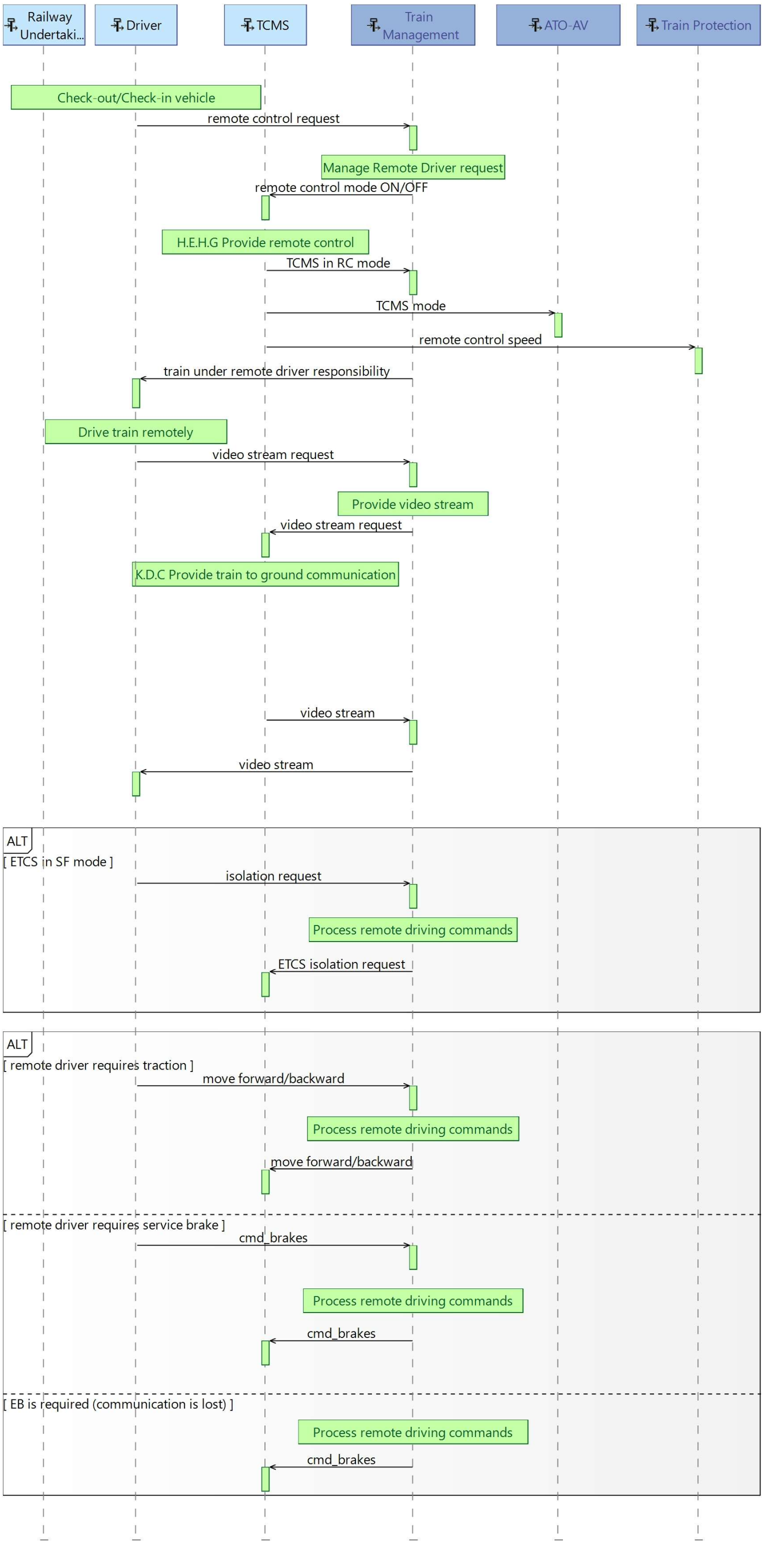
The remote driving mode is only possible with TCMS in remote control mode. Other commands can be sent to TCMS, but they do not correspond to a remote driving like the reset of a passenger alarm or the locking of a coach for example.

The communication channel for remote control must be safe. Cybersecurity and delays must be considered. A loss of communication must lead to brake application. Remote driving implies a robust communication system (coverage levels are specified in UIC 951 with a coverage probability of 95 %).

A specific lamp is required on the train to inform that train is under control (autonomous mode or remote control).

When he takes over the commands, remote driver should check that the train can be driven in remote control. If TCMS has failed, remote driver will ask for rescue.
Remote driver should receive from IPM-TS and TMS all needed data to perform the movement.

Note: The logical architecture could evolve according to the remote control needs and the sharing of responsibilities between RU and IM. A remote driver in charge of several types of train could be a new role allocated to IM in the future for example.

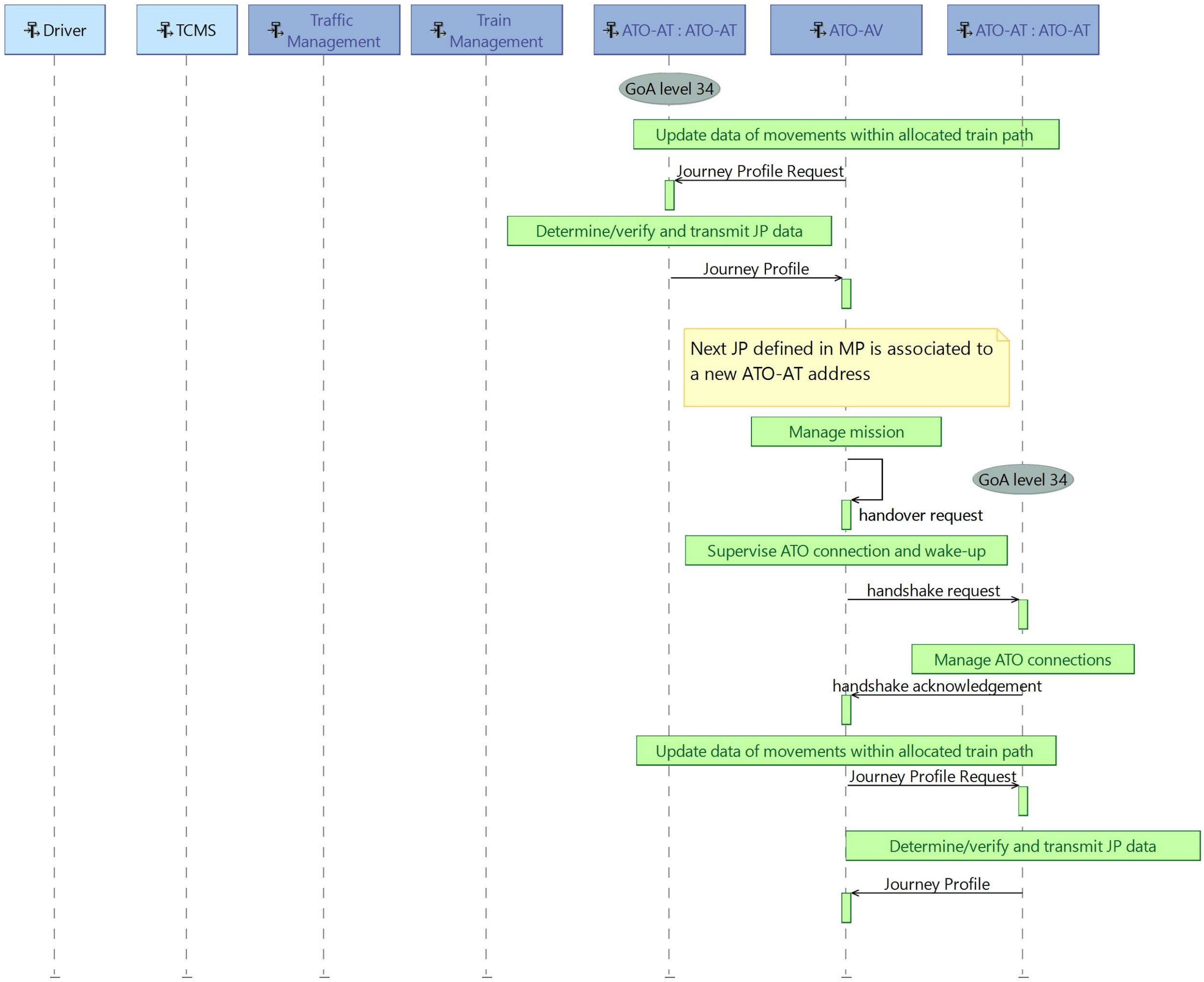


Railway Undertaki...
Driver
TCMS
Train Management
ATO-AV
Train Protection
Check-out/Check-in vehicle
remote control request
Manage Remote Driver request
remote control mode ON/OFF
H.E.H.G Provide remote control
TCMS in RC mode
TCMS mode
remote control speed
train under remote driver responsibility
Drive train remotely
video stream request
Provide video stream
video stream request
K.D.C Provide train to ground communication
video stream
video stream
ALT
[ ETCS in SF mode ]
isolation request
Process remote driving commands
ETCS isolation request
ALT
[ remote driver requires traction ]
move forward/backward
Process remote driving commands
move forward/backward
[ remote driver requires service brake ]
cmd_brakes
Process remote driving commands
cmd_brakes
[ EB is required (communication is lost) ]
Process remote driving commands
cmd_brakes

## 12.14 Transitions

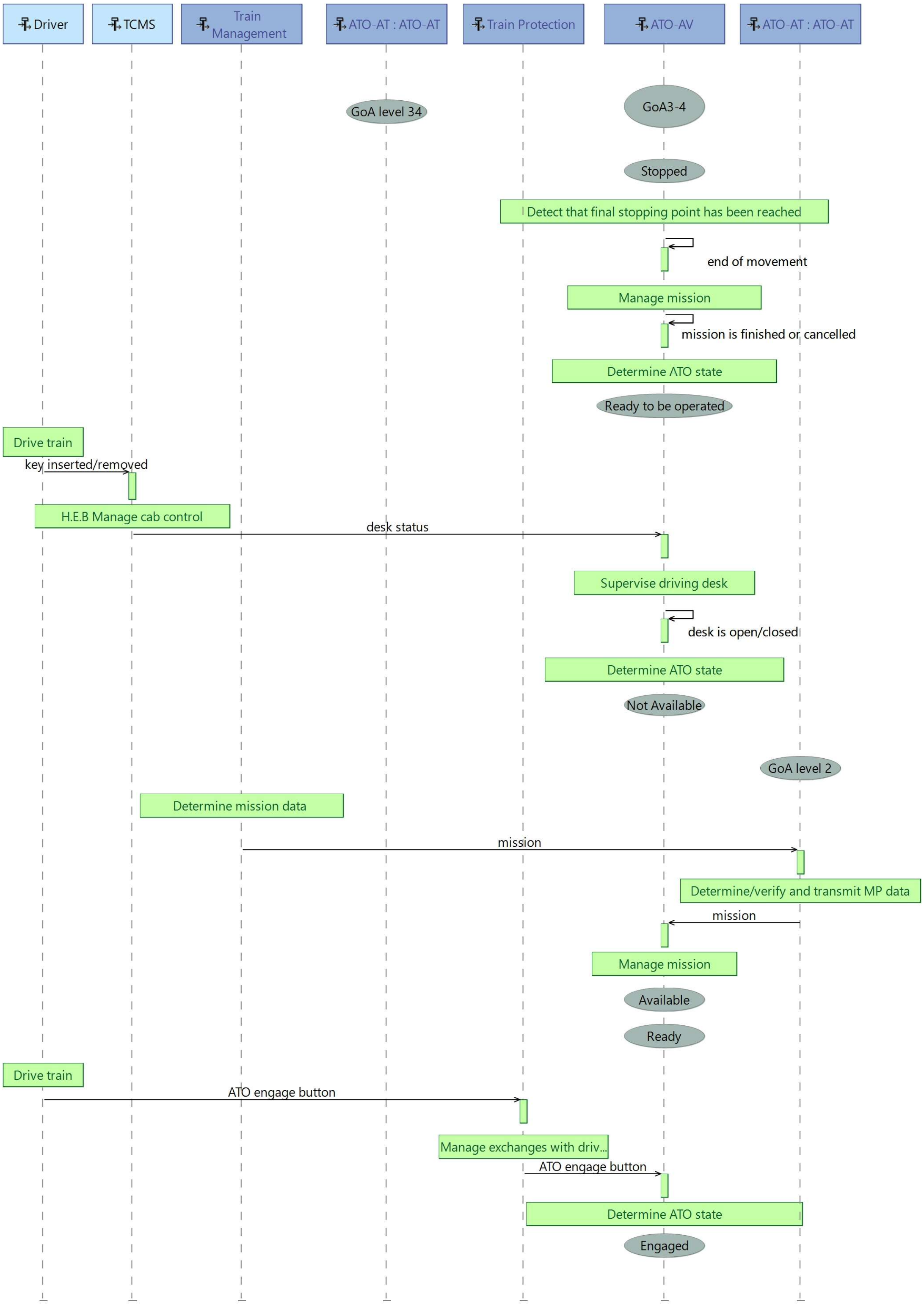
### 12.14.1 Border crossing (GoA34 to GoA34)

This Use Case relates to the handover between two GoA34 areas of different countries.




### 12.14.2 Border crossing (GoA34 to GoA2)

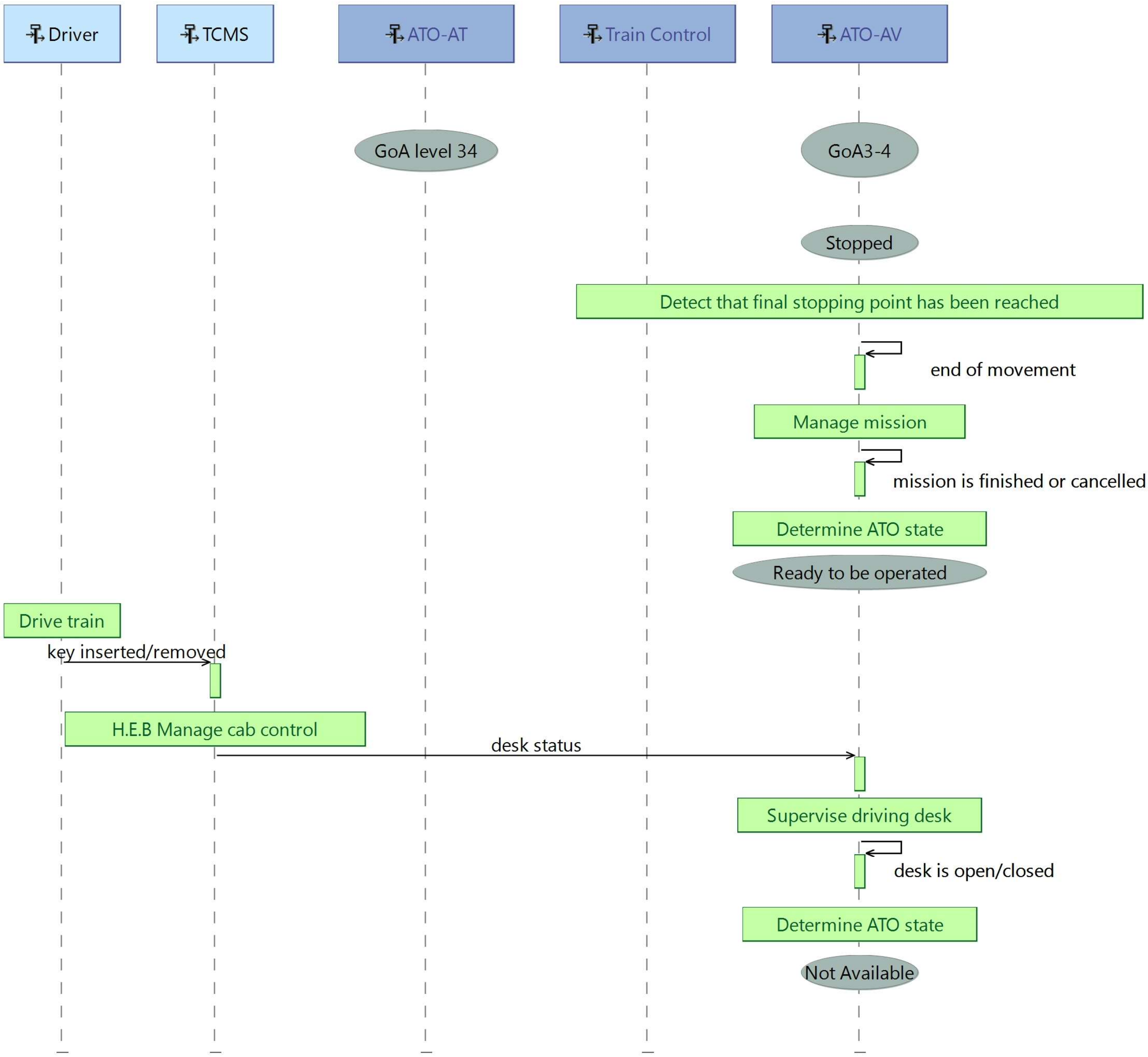
This Use Case relates to a GoA4 train equipped with a driving desk. It shows how the driving responsibility is transferred from GoA4 to the driver (transition OC1->OC3 of chapter 8.2).



Driver
TCMS
Train Management
ATO-AT : ATO-AT
Train Protection
ATO-AV
ATO-AT : ATO-AT
GoA level 34
GoA3-4
Stopped
Detect that final stopping point has been reached
end of movement
Manage mission
mission is finished or cancelled
Determine ATO state
Ready to be operated
Drive train
key inserted/removed
H.E.B Manage cab control
desk status
Supervise driving desk
desk is open/closed
Determine ATO state
Not Available
GoA level 2
Determine mission data
mission
Determine/verify and transmit MP data
mission
Manage mission
Available
Ready
Drive train
ATO engage button
Manage exchanges with driv...
ATO engage button
Determine ATO state
Engaged

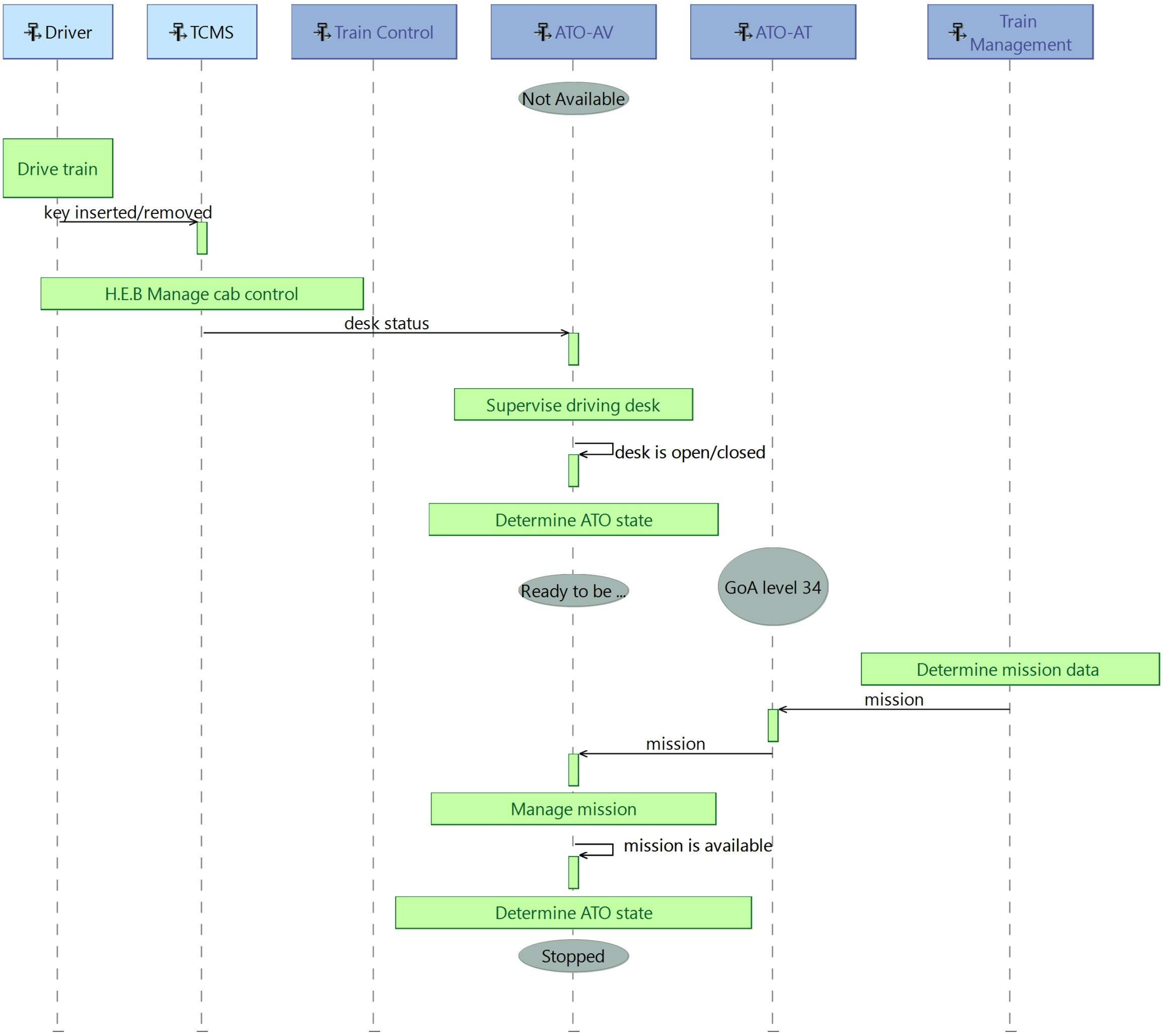
### 12.14.3 Border crossing (GoA34 to GoA01)

This Use Case relates to a GoA4 train equipped with a driving desk. It shows how the driving responsibility is transferred from GoA4 to the driver (transition OC1->OC4/OC5 of chapter 8.2).




### 12.14.4 Border crossing (GoA01 to GoA34)

This Use Case relates to a GoA4 train equipped with a driving desk. It shows how the driving responsibility is transferred from the driver to GoA4 (transition OC4/OC5->OC1 of chapter 8.2).



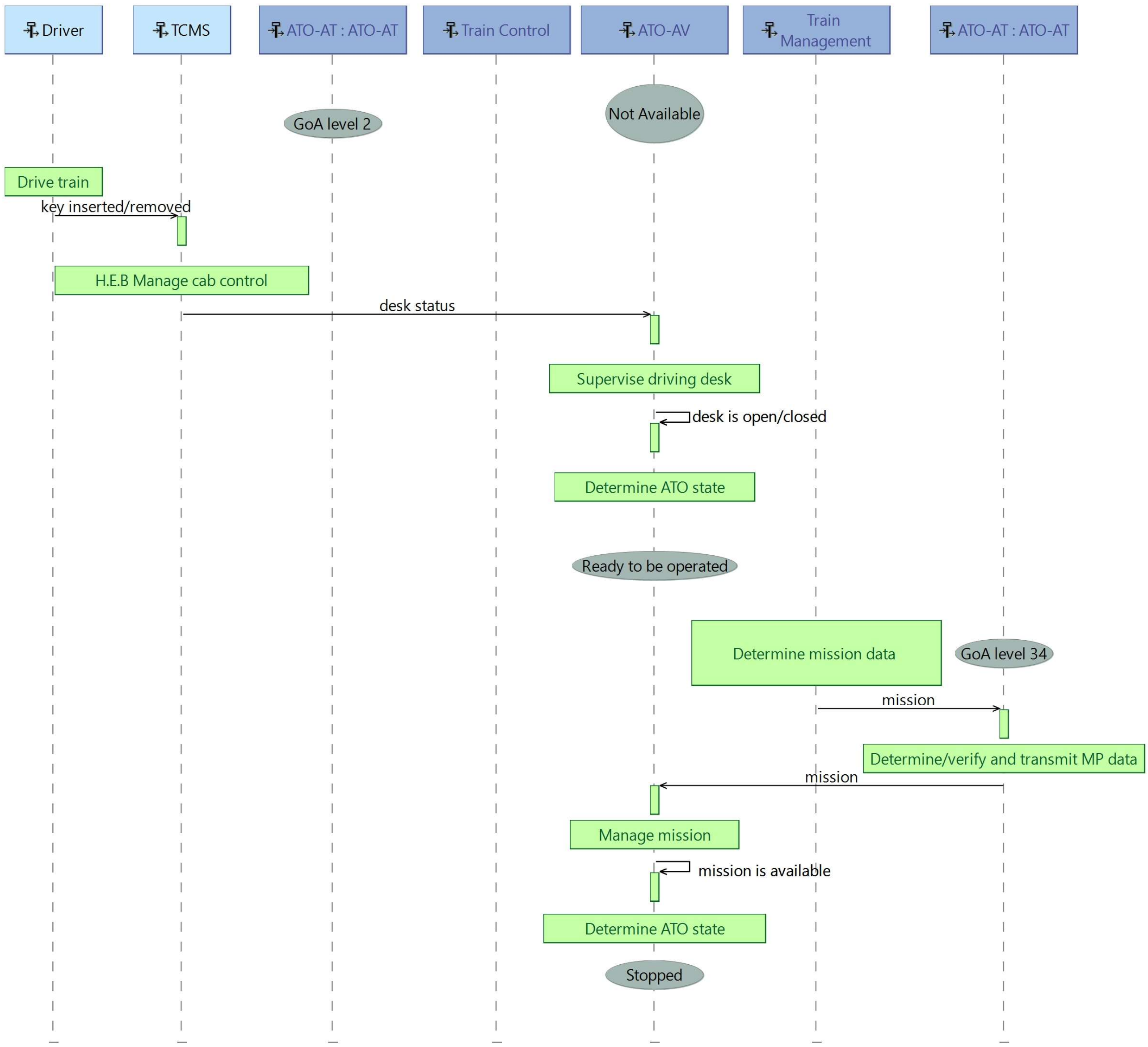

### 12.14.5 Border crossing (GoA2 to GoA34)

This Use Case relates to a GoA4 train equipped with a driving desk. It shows how the driving responsibility is transferred from the driver to GoA4 (transition OC3->OC1 of chapter 8.2).

Description

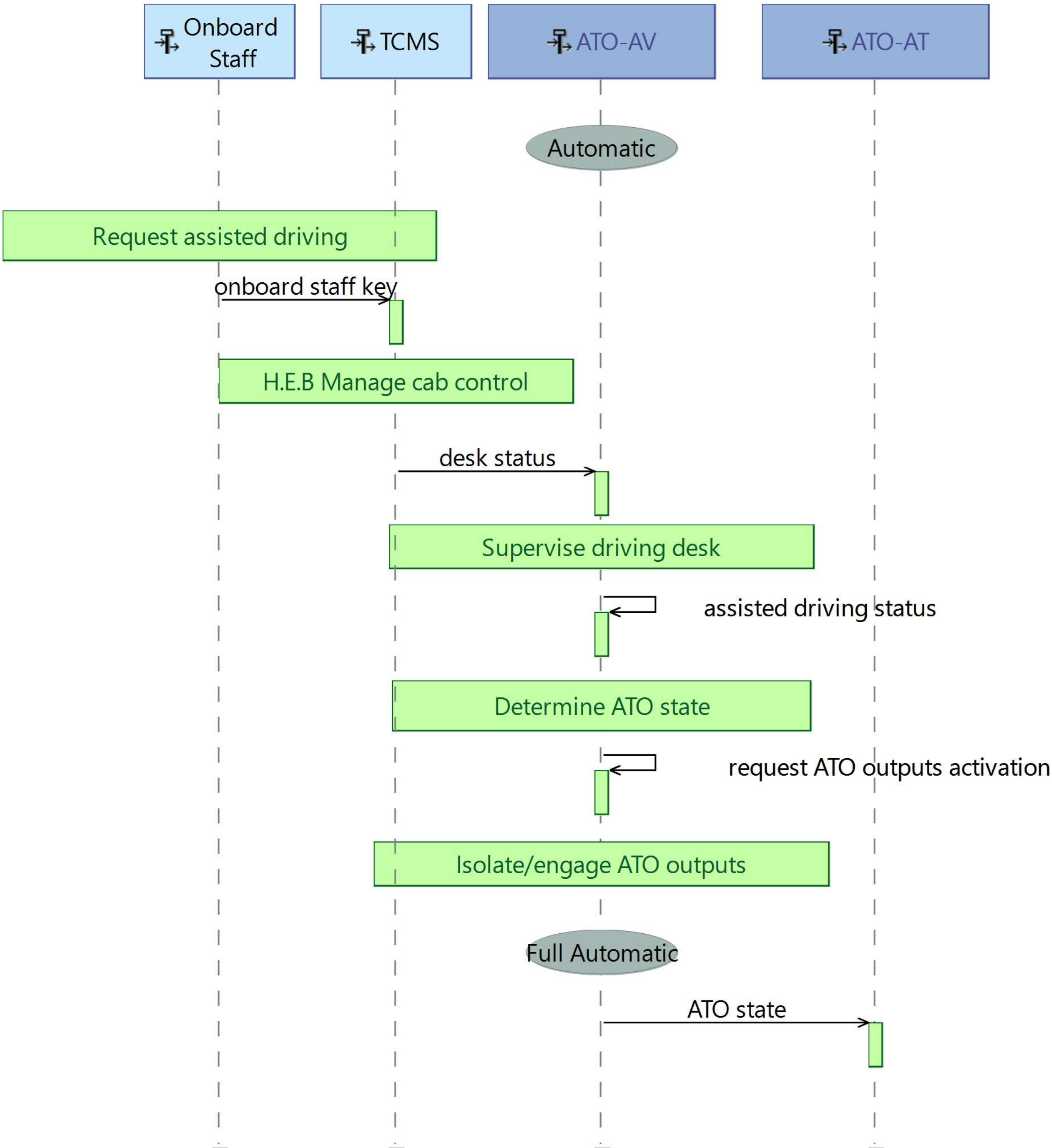
This Use Case describes the nominal case where there is no driver already present.

A transition on the fly is possible in very specific circumstances like a long tunnel for example where the driver can let the train run automatically. This case corresponds to a GoA34 area defined inside a GoA2 area where the transition was performed according to the nominal case.



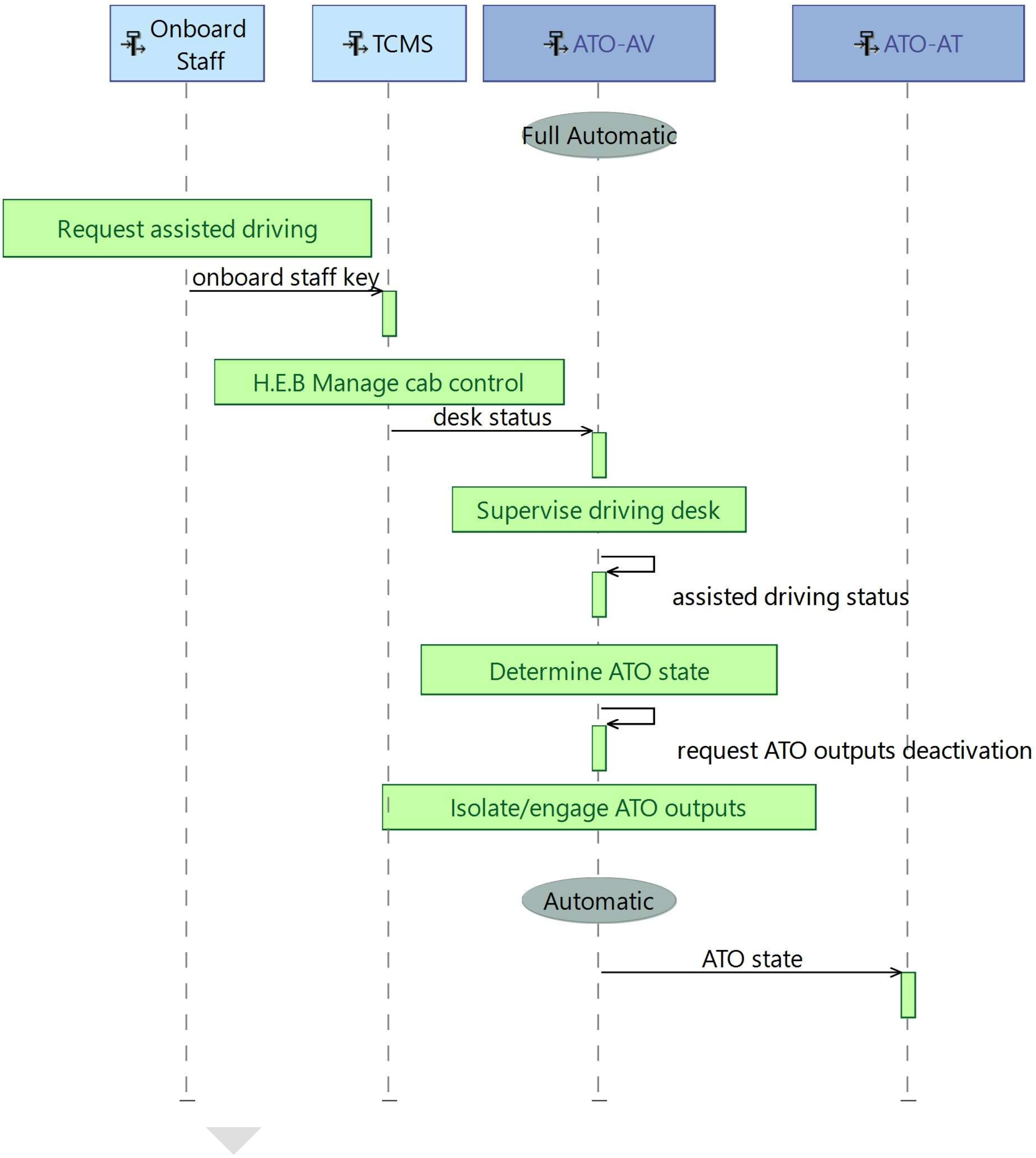

### 12.14.6 Change of running context (GoA3 to GoA4)

This Use Case relates to a GoA4 train equipped with a driving desk. It shows how specific functions are transferred from train attendant to GoA4 (transition OC2->OC1 of chapter 8.2).




### 12.14.7 Change of running context (GoA4 to GoA3)

This Use Case relates to a GoA4 train equipped with a driving desk. It shows how specific functions are transferred from GoA4 to train attendant (transition OC1->OC2 of chapter 8.2).


Onboard Staff
TCMS
ATO-AV
ATO-AT
Full Automatic
Request assisted driving
onboard staff key
H.E.B Manage cab control
desk status
Supervise driving desk
assisted driving status
Determine ATO state
request ATO outputs deactivation
Isolate/engage ATO outputs
Automatic
ATO state

# 13 Description of Data

## 13.1 Introduction

13.1.1.1.1 This chapter details the Exchange Items introduced in chapter 10 to characterize the interfaces between logical components.

13.1.1.1.2 Each Exchange Item is an abstraction grouping several functional exchanges of the same nature. It permits to make the link with a data model composed of classes (example: mission), complex types (example: date with year, month and day) and simple types (example: Boolean). Relationships between data are modelled with class diagrams.

13.1.1.1.3 The current data model is limited to Exchange Items with a high-level description for the purpose of a functional specification, they are not categorized in inputs or outputs. Next step is to define libraries for development phase where each description will be modelled with relevant classes, types and class diagrams.

13.1.1.1.4 This chapter will thus evolve to replace the current descriptions by a data model. At the end, it is expected that this chapter will be replaced by specific documents generated from the related libraries i.e. one document for each interface under the scope of GoA34. Like for the current subset documents, inputs and outputs will be detailed in separate chapters.

## 13.2 ATO data

### 13.2.1 ATO identity card

| |
|---|
| The identity card is composed of:<br><br>- Single unit / multiple unit status<br><br>- ATO number and version of related software (M_ATO_version)<br><br>- Vehicle number controlled by the ATO<br><br>- In case of multiple units, the number of each coupled ATO with the corresponding vehicle number and the composition sequence<br><br>- Operational train running number (NID_OPERATIONAL will be updated for each JP defined in the mission)<br><br>- Train Management number (RU Server address).<br><br>Note: A consist number can also be used but there should be a univoque relationship |

| |
|---|
| between a consist and the vehicle of the consist hosting ATO. |

### 13.2.2 Coupling authorization

| |
|---|
| Coupling authorization:<br>- coupling authorization not given = 0<br>- coupling authorization given = 1<br>- Timing point where the Train Unit to be joined is expected, the closest one to the end of the train to be coupled (independent from the use of the MA). |

### 13.2.3 Handshake acknowledgement

| |
|---|
| See SS-126, HSAck packet. |

### 13.2.4 Handshake request

| |
|---|
| See SS-126, HSReq packet. |

### 13.2.5 Journey incidents

| |
|---|
| Journey incidents to be communicated to passengers (justification for a delay...). |

### 13.2.6 Journey Profile

| |
|---|
| A Journey Profile defines the route of the train by listing the Segment Profiles which will be travelled by the train. It contains (see subset-125):<br><br>- Status of the Journey Profile<br><br>- Train route data<br><br>- Operational data<br><br>- Dynamic infrastructure data required to operate (Temporary Constraints). |

### 13.2.7 Journey Profile request

| |
|---|
| See SS-126, JP request packet. |

### 13.2.8 Mission Profile

The Mission Profile (MP) gives the list of Journey Profile ID(s) agreed with IM(s) and defines the tasks to be performed on the Train Unit during the timeslots not dedicated to a journey.

The mission characteristics must be defined for each consist:

- Identification number

- Date of the mission

- Beginning time of the mission

- Ending time of the mission (to be confirmed)

- Consist number (for check)

- List of Journey Profiles numbers with for each JP:

* ATO-AT address

* Foreseen train composition (single, double, length and weight for cargo or coach)

* Place of the consist into the train (leading or not)

* Train mode (functional or hauled vehicle, with passenger service or empty, with wagons or without wagons)

* GoA1/GoA2/GoA3/GoA4/remote driving

* State of the train before and after the journey (start-up time / shutdown time, retention of service, energy saving)

* Time to release door before departure (optional)

* Unscheduled operation before and after JP with services like sand refuelling, water refuelling or fluids refuelling for self-propelling trains with local ATO-AT address (optional)

* Coupling/decoupling in depot yard unscheduled with local ATO-AT address (optional)

* Unscheduled movement to first station with local ATO-AT address (optional)

* Coupling or uncoupling cargo wagon with local ATO-AT address or on-site function

(optional)

* For catering and cleaning, door release time, time window, energy mode (optional)

* Tasks, if not performed automatically by TCMS, as a set of predefined remote operations done between JPs (optional): heating/cooling time before departure, brake test, ATP test, ORD data collection.

Each task is identified with a unique number containing the starting date of the task and the mission ID. Each task includes an indicative starting time and a duration. The task has an attribute informing if the task must be started automatically at a precise time or in a defined interval with an order of RU. In case of delay, an alert is transmitted to RU.

A mission can contain an empty task bounded with an entry/exit location and time. This task will be completed by RU and transmitted as a modification of mission but if it is not done, the train will be stopped at the entry location and a request to continue will be sent. The empty task can be used to define local movements without JP like between a maintenance yard and a technical centre (supervision by a local TMS/interlocking).

### 13.2.9 Mission Profile request

A Mission Profile request can be sent to receive a new mission or a new task in the Mission.

### 13.2.10 Segment Profile

See SS-126, SP packet.

### 13.2.11 Segment Profile request

See SS-126, SP request packet.

### 13.2.12 Service Brake efficiency

ATO information associated to the dynamic test of the brakes at certain locations in GoA34.

### 13.2.13 Status Report

See SS-126, SR packet.

#### 13.2.14 TIS information

TIS information groups various data transmitted to passengers.

#### 13.2.15 TPS order

TPS order corresponds to a specific request from Train Preparation Staff:

- apply brake request

- release brake request

- brake release ok

- electro-pneumatic brake test ok

- request coupling

- coupling ok

- request compression

- uncoupling OK

- request train wake-up.

#### 13.2.16 Train report details

This report collects the status of the various train systems that are necessary to perform a mission.

## 13.3 DMO data

### 13.3.1 Infrastructure static data

Given in SS126 via segment profile. In addition some GoA4 specific (e.g. location mark for signals, etc.).

- rescue points
- door-opening possible sides
- ATO inhibition zones for different GoA levels
- Altitude info

- Speed limits
- Speed limits depending on train categories
- Speed limits depending on axle load
- Gradient info
- Curve info
- Voltage info
- Traction system info
- Current info
- Balise info
- Tunnel info
- Bridge info
- Powerless section info
- Brakes switch off areas
- non-stopping areas
- dangerous buildings or track elements
- permitted brake distances (?)

- platform parameters
- stopping point parameters
- horn activation locations
- level crossing to run with caution speed

With C34, DMO has a direct access to DMT. SP information could go through this interface with an update of SS-126 to keep only the list of SP IDs in JP.

### 13.3.2 Infrastructure dynamic data

Track parameters subject to dynamic conditions (low adhesion, flooding, level crossing failure...). They can be managed by track conditions but also via a dynamic layer of DMO.

Note: JP is more dynamic than DMO. What is the update frequency of DMO?

## 13.4 IPM data

### 13.4.1 Action for ATO

The following actions are expected:

- full service brake

- service brake to slow down

| |
|---|
| - service brake to rescue point<br><br>- door closure forced (door failure detected)<br><br>- msg to remove obstacle from door<br><br>- cmd battery protection mode. |

### 13.4.2 Action for Train Protection

| |
|---|
| The following actions are expected:<br><br>- ES<br><br>- Obstacle MA<br><br>- Horn request<br><br>- cmd emergency pantograph drop<br><br>- pantograph drop request |

### 13.4.3 Action for TCMS

| |
|---|
| Related to cmd_ventilation_without_energy (window opening for example). |

### 13.4.4 Infra static data

| |
|---|
| Well-known infrastructure elements that can be used by perception to avoid false alarms. The knowledge of the track permits for example to focus on the area of interest. |

### 13.4.5 Local alarm

| |
|---|
| Boolean for activating (1) a local alarm or not (0). All trains running in the vicinity of the train having generated this alarm must be stopped. |

### 13.4.6 Monitoring

| |
|---|
| The following checks are identified: |

| |
|---|
| - absence of passengers in the train<br><br>- surroundings OK (for train departure). |

### 13.4.7 Order for ATO

| |
|---|
| The following orders are identified:<br><br>- authorization to close the doors<br><br>- authorization to proceed<br><br>- start prohibited<br><br>- physical immobilization. |

### 13.4.8 Order for SCV

| |
|---|
| Orders for SCV (to be completed in TAURO project). |

### 13.4.9 Supervision orders

| |
|---|
| The following orders are expected from trackside:<br><br>1. authorization to close the doors: door close command (Set of Integer)<br><br>2. battery protection request<br><br>3. pantograph drop request<br><br>4. physical immobilization<br><br>5. authorization to proceed<br><br>6. speed restriction (for SCV)<br><br>7. override process (for SCV)<br><br>8. caution speed on 1000m (for SCV)<br><br>Remark: |

- Type of door close command: close all doors, recycle open doors.
- Manual commands to support resolving an incident should be part of overall set of commands from operations manager.

### 13.4.10 Track incident report

On track:

1. Type of track anomaly (Set of Integer)
2. Position of track anomaly (segment no, distance)
3. Time of detection: come
4. Time of detection: gone

Beside track:

1. Type of track anomaly (Set of Integer)
2. Position of track anomaly (segment no, distance)
3. Time of detection: come
4. Time of detection: gone
5. Distance to center of track (Integer in 1m)

Remark:
- Type of incidents on track: person, children, animal, fire, smoke, tree, car, avalanche, landslide, broken catenary, unknown object.
- Type of incidents beside track: person, children, animal, fire, smoke, tree, car, avalanche, landslide, broken catenary, unknown object.

### 13.4.11 Train incident report

1. Type of train anomaly (Set of Integer)
2. Position of train anomaly (car number)
3. Time of detection: come
4. Time of detection: gone

Remark:
- Type of anomalies of train: brake capability, traction capability, speed restriction, pantograph, horn, head light, passenger doors, HVAC, coupler, etc.

### 13.4.12 Train Protection information

| |
|---|
| Train Protection information (MA, ETCS mode). |

### 13.4.13 Train restriction

The following train limitations must be taken into account:

- air suspension isolated
- axle restriction
- door restriction
- degraded braking capacity
- degraded traction capacity
- fluid level for non-electric engines
- main battery no more charging
- catenary voltage
- loss of voltage (request coasting)
- pantograph restriction
- horn disturbed
- train consist failure.

## 13.5 LS data

### 13.5.1 Signal information

| |
|---|
| Optical signs providing information and /or orders to the trains (manually or automatically driven). |

## 13.6 LZ data

### 13.6.1 Train position

| |
|---|
| Train position on a track with associated travelling direction and orientation (roll, pitch, yaw).<br><br>See SS-026 D_LRBG for a relative distance to a fixed location defined in DMO:<br><br>- 15 bits<br><br>- range: 0cm - 327.660 km<br><br>- resolution: 10 cm, 1m or 10 m (depends on Q_SCALE). |

### 13.6.2 Train speed

| |
|---|
| Different resolutions are possible depending on application:<br><br>- V_EST (SS-130): 1 cm/s<br><br>- V_TRAIN (SS-026): 5 km/h<br><br>- V_TRAIN_ATO (SS-126): 1 km/h. |

### 13.6.3 UTC time

| |
|---|
| Universal Time Coordinated. |

## 13.7 ORD data

### 13.7.1 ATO_to_ORD

| |
|---|
| Data to be recorded in the ORD. The data set (variables) and format (packets) are defined in Subset 140. |

### 13.7.2 ORD_to_ATO

| |
|---|
| ORD confirmation that its memory capacity is not full. |

## 13.8 PE data

### 13.8.1 Anomaly on adjacent track detected

| |
|---|
| The following incidents are identified:<br><br>- body discovered<br><br>- catenary damage<br><br>- flooding<br><br>- track anomaly. |

### 13.8.2 Anomaly on current track detected

| |
|---|
| The following incidents are identified:<br><br>- body discovered<br><br>- catenary damage<br><br>- flooding<br><br>- track anomaly<br><br>- livestock wandering<br><br>- strucked person. |

### 13.8.3 Anomaly on rear track detected

| |
|---|
| Incident detected by rear view (dragging equipment, catenary damage...). |

### 13.8.4 Axle rotation detected

| |
|---|
| Detection of an axle movement at low speed for checking hot box. |

### 13.8.5 Crossing train detected

| |
|---|
| The following events are identified:<br><br>- crossing train (for dipped/headlights)<br><br>- sparks on a roof<br><br>- anomalies detected on crossing train<br><br>- runaway train. |

### 13.8.6 Fire on embankment detected

| |
|---|
| Fire or heavy smoke on embankment. |

### 13.8.7 Infrastructure object detected

| |
|---|
| Infrastructure object identified in Digital Map: buffer stop, equipment room, catenary mast, environmental barriers, level crossing barriers.<br><br>An anomaly on the object can be reported for maintenance purpose. |

### 13.8.8 Railway agent detected

| |
|---|
| Railway agent or railway agent signal. |

### 13.8.9 Railway agent signal detected

| |
|---|
| Hand signal or red light flare. |

### 13.8.10 Train anomaly detected

| |
|---|
| The following anomalies are identified:<br><br>- abnormal noise on the car body<br><br>- abnormal train body dynamics<br><br>- anomalies on a train side |

| |
|---|
| - unusual impact. |

#### 13.8.11 Train interior event detected

| |
|---|
| The following events are identified:<br><br>- suspicious luggage detected<br><br>- inappropriate passenger behavior<br><br>- presence of a passenger inside the train before leaving for a depot. |

#### 13.8.12 Vehicle detected

| |
|---|
| Event used in coupling operation. |

## 13.9 PER data

### 13.9.1 Cmd_axle inspection

| |
|---|
| Boolean for requesting axle inspection (1) or not (0). |

### 13.9.2 Cmd_video

| |
|---|
| Request for access to PER video. |

### 13.9.3 Msg_anomaly_on_adjacent_track

| |
|---|
| The following incidents are identified:<br><br>- body discovered<br><br>- catenary damage<br><br>- flooding<br><br>- track anomaly |

| |
|---|
| - broken or buckled track. |

### 13.9.4 Msg_anomaly_on_current_track

| |
|---|
| The following incidents are identified:<br><br>- body discovered<br><br>- catenary damage<br><br>- flooding<br><br>- track anomaly<br><br>- livestock wandering<br><br>- broken or buckled track. |

### 13.9.5 Msg_approaching_train_anomaly

| |
|---|
| Anomalies on train ahead (front light or rear light missing...). |

### 13.9.6 Msg_axle_status

| |
|---|
| Axle status: blocked or free. |

### 13.9.7 Msg_body_discovered

| |
|---|
| Strucked person detected along the current track or adjacent track. |

### 13.9.8 Msg_coupler_compression

| |
|---|
| 1. Current distance (Integer in 1cm resolution)<br>2. Current distance (Longinteger in 10cm resolution)<br><br>Remark:<br>-To clearly identify compression movement for uncoupling with high resolution but small distance.<br>-For precise approaching movement for coupling with medium resolution but longer |

| |
|---|
| distance. Distance to buffers or automatic couplers to be measured. |

### 13.9.9 Msg_crossing_train

| |
|---|
| 1. Opposite Train present/not present (Boolean yes/no)<br>2. Distance to opposite train (Integer in 1m resolution)<br><br>Remark:<br>-If train is just passing ego train, distance is 0 and Presence is still yes.<br>-The minimum distance for dipping the headlights needs to be defined (maybe subject to national values). |

### 13.9.10 Msg_crossing_train_anomaly

| |
|---|
| Anomalies on crossing train (front light or rear light missing, wagon losing its cover, uncontrolled...). |

### 13.9.11 Msg_embankment_fire

| |
|---|
| Fire or heavy smoke detected on embankment. |

### 13.9.12 Msg_infra_object_anomaly

| |
|---|
| The anomalies currently identified are:<br><br>- level crossing damage. |

### 13.9.13 Msg_obstacle

| |
|---|
| Type of obstacle detected + distance. |

### 13.9.14 Msg_railway_agent_presence

| |
|---|
| The presence of a railway agent in protection zone is authorised by IM and should not lead to a false alarm. The agent should be identified as such by Perception thanks to his protection jacket. |

### 13.9.15 Msg_railway_agent_signal

| |
|---|
| The railway agent has several means to inform the driver of an approching train. He can raise one hand to acknowledge a horn signal or communicates an emergency through the use of a red light flare or by moving his two hands). |

### 13.9.16 Msg_sensor_efficiency

| |
|---|
| Sensor Visibility Range (Integer 10m resolution)<br><br>Remark:<br>- To reduce speed in case of low visibility.<br>- To include in incident report. |

### 13.9.17 Msg_track_video

| |
|---|
| Packet to send video stream from PER to TCMS/Train Management (no UC today, it is an available option). |

### 13.9.18 Msg_train_anomaly

| |
|---|
| The following anomalies are identified:<br><br>- abnormal noise on the car body<br><br>- abnormal noise on the roof<br><br>- abnormal train body dynamics<br><br>- high voltage anomaly<br><br>- anomalies on train sides<br><br>- anomalies on train rear. |

### 13.9.19 Msg_train_interior_anomaly

| |
|---|
| The following events are identified: |

| |
|---|
| - suspicious luggage detected<br><br>- inappropriate passenger behavior<br><br>- train clear of passengers (Boolean yes/no). |

#### 13.9.20 Msg_vehicle_or_buffer_stop

| |
|---|
| 1. Trainset or Wagon present/not present on ego track (Boolean yes/no)<br>2. Current distance (Longinteger in 10cm resolution)<br><br>Remark:<br>-Could also be used for close stabling, i.e. without coupling. |

### 13.10SCV data

#### 13.10.1 Next signal position

| |
|---|
| It gives the next signal position sent to PER by SCV (to be completed in TAURO project). With DMO and SP in JP, SCV calculates position and nature of next expected signal to be recognized by perception. |

#### 13.10.2 Signal aspect

| |
|---|
| ID of signal, signal type, signal aspect, distance to signal (to be completed in TAURO project). Signal aspect as described in Eulynx signal aspect table.<br><br>Note: temporary signals are not part of DMO. Perception should look at them continuously. |

#### 13.10.3 Tauro information

| |
|---|
| Information will be detailed in Tauro project. |

### 13.11TCMS data

#### 13.11.1 Cmd_brakes

| |
|---|
| Application or release of Service brake or Direct brake.<br><br>For Holding brake, it is limited to a request (application and release are managed by |

| |
|---|
| TCMS). |

### 13.11.2 Cmd_coupler

| |
|---|
| The coupler command activates the splitting of a Train Unit or prepares the coupling of two consists. It opens or closes the trapdoor and activates heating in case of winter conditions. |

### 13.11.3 Cmd_doors

| |
|---|
| The door command includes intelligent door system commands relevant for ATO. |

### 13.11.4 Cmd_EB

| |
|---|
| Command for Emergency Brake. |

### 13.11.5 Cmd_horn

| |
|---|
| Horn on or off. |

### 13.11.6 Cmd_headlights

| |
|---|
| Boolean for headlights activation (1) or deactivation (0) to pass from headlights to dipped headlights. |

### 13.11.7 Cmd_power_on

| |
|---|
| Request to raise pantograph for electric engine or start non-electric engine. Feedback is given by TCMS mode. |

### 13.11.8 Cmd_sand_inhibition

| |
|---|
| Boolean for sandbox activation (0) or inhibition (1). |

### 13.11.9 Cmd_TCMS_mode

| |
|---|
| ATO request for changing current TCMS mode. |

### 13.11.10 Cmd_train_orientation

Driving desk is virtual in GoA4, it corresponds to the train front end selected by the mission.

### 13.11.11 Cmd_traction

Traction requested by ATO.

### 13.11.12 Cmd_vigilance_inhibition

Boolean for vigilance activation (0) or inhibition (1).

### 13.11.13 Msg_adhesion

SUBSET-139-0016
7.3.3 TCMS to ATO packet - fast data,
M_TCMS_AvaAdh = 0 : bad adhesion /slippery
Feedback information to transmit driving anomalies about grip/ground adhesion.

### 13.11.14 Msg_brakes

SUBSET-139-0016
6.2.7 Train and vehicle specific values - T/B set value
(Numerical) Current value of TCMS traction/brake control signal
7.3.3 TCMS to ATO packet - fast data,
(BITSET) Q_TCMS_BrakeStat - Brake status - Auxiliary logical control signals for pneumatic brakes control
Included FIS signals: EB released, SB applied, Holding Brake applied, Direct brake applied, Traction over brake enabled.

### 13.11.15 Msg_coupler

Information provided by TCMS to ATO-AV to inform that physical splitting or coupling is completed.

### 13.11.16 Msg_desk

Desk status: indicates if a cab is selected by the driver or not.

#### 13.11.17 Msg_doors

| |
|---|
| The door message includes intelligent door system information relevant for ATO.<br><br>SUBSET-139-0016<br>6.2.6 Door control signal, Door status signals<br>Feedback signal - the actual status of doors: door control is available, all doors closed and locked (side selective)<br><br>7.3.3 TCMS to ATO packet - fast data:<br><br>Q_TCMS_DoorStat, bit0 = door control available<br><br>Q_TCMS_DoorStat, bit1 = all left doors closed and locked, bit2 = all right doors closed and locked<br><br>Q_TCMS_DoorStat, bit3 = doors released |

#### 13.11.18 Msg_EB

| |
|---|
| Feedback of Emergency Brake application. |

#### 13.11.19 Msg_headlights

| |
|---|
| Boolean for headlight status ON (1) or OFF (0). |

#### 13.11.20 Msg_horn

| |
|---|
| Information provided by TCMS to ATO to inform about the status and possible failure of the horn. |

#### 13.11.21 Msg_incident

| |
|---|
| Incidents impacting operation:<br><br>- main battery is no more charging. |

### 13.11.22 Msg_local_protection

| |
|---|
| Feedback to give current protection state about collection devices and catenary. |

### 13.11.23 Msg_TCMS_mode

| |
|---|
| TCMS mode (service retention mode (stand-by), shutdown mode, remote control...). |

### 13.11.24 Msg_traction

| |
|---|
| SUBSET-139-0016<br>6.3.2 Traction /Dynamic Brake Control - Traction applied<br>(Boolean) feedback signal - propulsion reports that traction is applied<br><br>6.2.7 Train and vehicle specific values - T/B set value<br>(Numerical) Current value of TCMS traction/brake control signal |

### 13.11.25 Msg_train_configuration

| |
|---|
| Train unit direction + count, order and capabilities of its consists after train inauguration process. |

### 13.11.26 Msg_train_parameters

| |
|---|
| The train parameters contain the following information:<br><br>A/ Composition number giving the type of train: MA (freight), ME, MV or V (passengers) and maximum authorized speed. Example: MA 100.<br><br>B/ Composition code: HLP (engine alone), TM (several engines), EVO<br><br>C/ Path number (for trains with allocated path)<br><br>D/ Departure date<br><br>E/ Destination<br><br>F/ Braking information, detailed for each vehicle (length, mass on rail, required braked mass, effective braked mass) and computed for the complete train.<br><br>This information must be updated at each change of composition or in case of brake |

isolation. Loco characteristics are considered including if they participate or not to the traction effort of the complete train. An abacus permits to determine the required braking mass in function of the mass on rail. A modification can modify the maximal speed of the train and thus, its composition number.

### 13.11.27 Msg_weather

Weather parameters deduced from sensors.

## 13.12 ATP data

### 13.12.1 ATO_to_ATP

SUBSET 130 010 - 7.3.1:

- Packet Number 0: ATO_ETCS_Status

- Packet Number 1: ATO_ETCS_DMI

- Packet Number 2: ATO_ETCS_Data_Entry_Need

- Packet Number 3: ATO_ETCS_Data_Entry_Request

- Packet Number 4: ATO_ETCS_Data_View_Values.

### 13.12.2 ATP_to_ATO

SUBSET 130 010 - 7.3.2:

- Packet Number 5: ETCS_ATO_Static

- Packet Number 6: ETCS_ATO_Dynamic

- Packet Number 7: ETCS_ATO_Driver_Inputs

- Packet Number 8: ETCS_ATO_Data_Entry_Values

- Packet Number 9: ETCS_ATO_Data_Entry_Flag

- Packet Number 10: ETCS_ATO_Data_View_Values_Request

# 14 Conclusions

The aim of this report has been to deliver the GoA34 specification to WP4 “ATO up to GoA4” Development. GoA34 specification (D3.2) and GoA2 specification (D3.1) collect the operator needs associated to the different Grade of Automation levels of ATO, specify the related system functions and define a common architecture to allocate them on standard logical components. Functional exchanges between these components define the interoperable or exchangeable interfaces that will be required to run in ATO over ETCS in various operational contexts.

The target operational context is a run in GoA4 where the new components “Perception” (PER) and “Incident and Prevention Management” (IPM) implement the functions ensured today by the driver in Main Line applications. The ultimate goal is unattended operation like for Urban applications but taking into account the specific features of the Railways (open environment, mixed traffic) that are source of various events (a fallen tree is not expected in metro for example). An intermediate step with driver supporting functions like in automotive sector should be expected during the validation phase of the new system.

The GoA34 specification will continue to evolve to take into account the results of the test tracks and safety analyses before to become a European standard like TSI 2022 for GoA2.

# 15 References

X2R4-WP03-T-ALS-008-09 X2R - GOA2 - APPLICABLE DOCUMENTS – 210415

SUBSET-026 – System Requirements Specification – version 3.6.0 - 13/05/2016

EN-15380-4 – Railway applications–Classification system for railway vehicles–Part 4: Function groups – 2013

IEC 61375-1 - Electronic railway equipment – Train Communication Network – General Architecture

UIC 612-1 - Rolling stock configurations and main activated functions for EMU/DMU, locomotives and driving coaches – January 2009

UIC 951 - EIRENE SRS - Version 16.0.0 - 21 December 2015

# Appendix A: Ownership of results

| Ownership of results | | | |
|---|---|---|---|
| **Company** | **Percentage** | **Short Description of share/ of delivered input** | **Concrete Result (where applicable)** |
| ALS | | Restricted use for prototype development | TSI preparation |
| BTSE | | Restricted use for prototype development | TSI preparation |
| STS | | Restricted use for prototype development | TSI preparation |
| RFI | | Restricted use for prototype development | TSI preparation |
| AZD | | Restricted use for prototype development | TSI preparation |
| CAFS | | Restricted use for prototype development | TSI preparation |
| MERMEC | | Restricted use for prototype development | TSI preparation |
| SMO | | Restricted use for prototype development | TSI preparation |
| TD | | Restricted use for prototype development | TSI preparation |
| SNCF | | Restricted use for prototype development | TSI preparation |
| SBB | | Restricted use for prototype development | TSI preparation |
| DB | | Restricted use for prototype development | TSI preparation |
| NR | | Restricted use for prototype development | TSI preparation |
| EUG | | Restricted use for prototype development | TSI preparation |

**Table 2: Ownership of results**