

# Rail to Digital automated up to autonomous train operation

## WP5.1 – Documentation of use cases for automating functions

### Annex 3: Defining Operational Actors

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## **ABBREVIATIONS AND ACRONYMS**

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## 1 INTRODUCTION

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This document aims at providing a reference for the operational entities/actors shared by the use-cases developed in WP 5.1, 5.2, 5.4.

All R2DATO WP5 partners are requested to use the definitions in this document as a common ground for defining the Use Cases. Partners are welcome to add new definitions if needed. Before adding to this document, please follow the steps in chapter 1.2 'convention'.

Additionally, a discussion is provided (chapter about how actors have been chosen, out of a pragmatic definition of what operational analysis (OA) is, Arcadia's flavour, and the relationship with current X2Rail-4 actors – as one constraint of R2DATO is to take over / merge WP5 with / into X2Rail's results.

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### 1.1 INPUTS

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It builds on existing assets:

- Actors in X2Rail-4' deliverable D5.1, "WP5 GoA3/4 Specification" version 0.3, chapter 9.
- FP2 R2DATO abbreviations and terminology, WP5 – Use case development guidance.
- Actors elicited by the work of WP5 itself.

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### 1.2 INTRODUCTION OF NEW ACTORS

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All R2DATO WP5 partners are requested to use the definitions in this document as a common ground for defining the Use Cases. Partners are welcome to add new definitions if needed. Please follow the steps below:

- Check if the actor you need is already in the document and if it suits your needs.
- If an actor is defined, but does not suit your needs – please add a review comment in the document so we can discuss changing/adding to the definition.
- If no such actor is defined, add the actor in a new table/chapter - including reference of your name/company as the one introducing the actor.

## 2 METHODOLOGICAL PREAMBLE

Operational analysis allows an operator to define its processes. Doing this, OA helps specify the IT or automation systems that will support its mission. As rule of thumb, the IT system shall mirror the operator's process landscape. The automation layers shall mirror the physical structure, or the technical actors implied in the system.

Therefore, a clear operational analysis permits to draw long standing architectures. For instance, a historical organizational entity of railways are stations. Each is defined by a track area (the entities responsibility) and a book of rules regulating the traffic in this area, applicable to all actors entering the area (shunting, station, interstation). The evolution of interlockings over the railway ages, the technical system automating the processes between technical actors in these areas, has continuously been hand in hand with those books of rules, to a point where functional specification of technical system and rule of book have grown identical.

On the contrary, while new processes are being automatized – decades of historical development are missing – technology driven processes arise, that comply with a tiny part of processes. When the technical systems start to grow, a tension may appear between the architecture of those technical systems and the process landscape, impacting the organization's performance. This tension is released only when processes are adapted (e.g., improvement enabled by the new technology), or the technical system's architecture is amended to mirror with the organization's existing processes. This last step may mean a costly redesign.

Focusing the analysis of an organization's processes permits use case authors to naturally focus on the processes and their needs, rather than the technical solution.

For instance, while trying to quality flank protection, a use-case author needs at first the concepts of train, switch (point), track, their geometries. The natural interactions between actors are of the 'approach', and 'collision' kind. In a second step, while describing how their movements shall be organized by the organization 'operations', made tangible by the role 'signaller', human responsible for the station area's processes, notions like journey, room exclusion, routes, movement authorities shall be added. The interactions can be described elegantly between signaller, track segments of the station area, train, switch, without technical system.

In no way, an interlocking is necessary: Introducing the interlocking may be easier for somebody used to having interlockings: the level of automation of this particular process area is so high that it may help to think of the interlocking as actor. However:

- thinking of how the interlocking organises the traffic is already thinking of the technological solution. This means, while considering the above tension between grown automation system and process area, keeping your focus on the system's solution, *i.e., if the solution was in tension*, disregarding the operational need.
- Introducing a technical system tends to require another: while a signal may notify a train its movement authority, an interlocking will rather communicate the movement authorities with the train's on-board ATP than with the train itself. Therefore, a notification that was between two operational actors now involves additionally two logical components. The messaging path has doubled by just adding for each role one technical system. Therefore, introducing technical components, while necessary at some point, at first complexifies and dilutes the description of needs, by exploding the messaging aspect.

As a summary, while organic technological growth is necessary to improve the whole system, once in a while *strictly considering operations* as they should be, permits to prepare efficient architecture amendments.

This chapter presents how actors have been identified for the project:

- Strictly operational actors, incl. humans or technical.
- Deviations and their rationales (Human Machine Interface (HMI), high-level automation systems).

## **2.1 HUMAN ACTORS: TAKE-OVER FROM X2RAIL**

A purpose of WP5 was to enrich current works of X2Rail-4, where both process-oriented and architecture-driver topics are interleaved in a single, with such an 'independent', text driven, operational view, which would be merged into X2Rail-4's architecture during WP6.

Even the strictest consideration is never completely independent: people defining the systems know partly the processes, and vice-versa. Therefore, while tailoring for a project, it is more pragmatic to consider the degree of independence, than an abstract independence that never fully exist. In WP5, many project members came from the technical solution, being also members of X2Rail-4, project still running at the same time as WP5.

The question of the degree of independence was raised while implicitly defining actors with the use-case prepared templates: some actors were logical components of X2Rail-4. As a result, some technical use-cases were issued, that were losing the focus on operations. For instance, for the emerging topics obstacle management, some use cases would emphasize only the recognition – not how the recognised obstacle should be handled by the train, or the organization e.g., in case of collision.

To keep the focus on operations, and gain independency from current solution, decision was made to maintain granularity above the X2Rail granularity of componentization (see below paragraphs about logical components).

## 2.2 OPERATIONAL ENTITIES

Operational entities are the organisational units / the process areas around the autonomous trains. They are presented in the chapter 'overview' and structure this document.

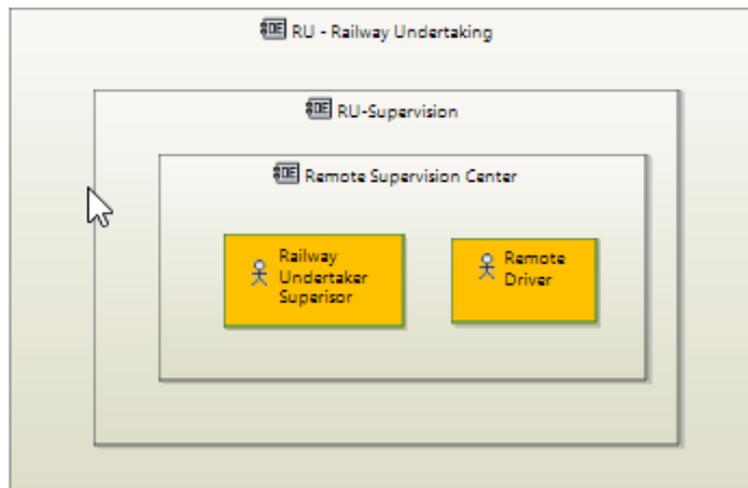
Those on the top are organisational units, as demanded by existing body of standards. They are mandatory in that they define where interfaces between components cannot be avoided. They are so implicit for all partner though (Railway Undertaking, Infrastructure Manager, Entity in Charge of Maintenance), that their mandatory status does not need to underline hereby.

Some entities are process areas of the 'top organisation' that seemed relevant to the project. They just seemed handy to structure thoughts: group human actors, use-cases, or as chapter of this document. They are not mandatory: the human actors they host are the keys that will define later the HMI required from the technical systems supporting those process areas.

As an example, In next figure, operational entities are presented:

- RU – Railway Undertaking: top organisational entity as demanded per standards.
- RU- Supervision, Remote Supervision Center: handy sub-organisations of RU.

Yellow colours are the operational actors – see next paragraph.

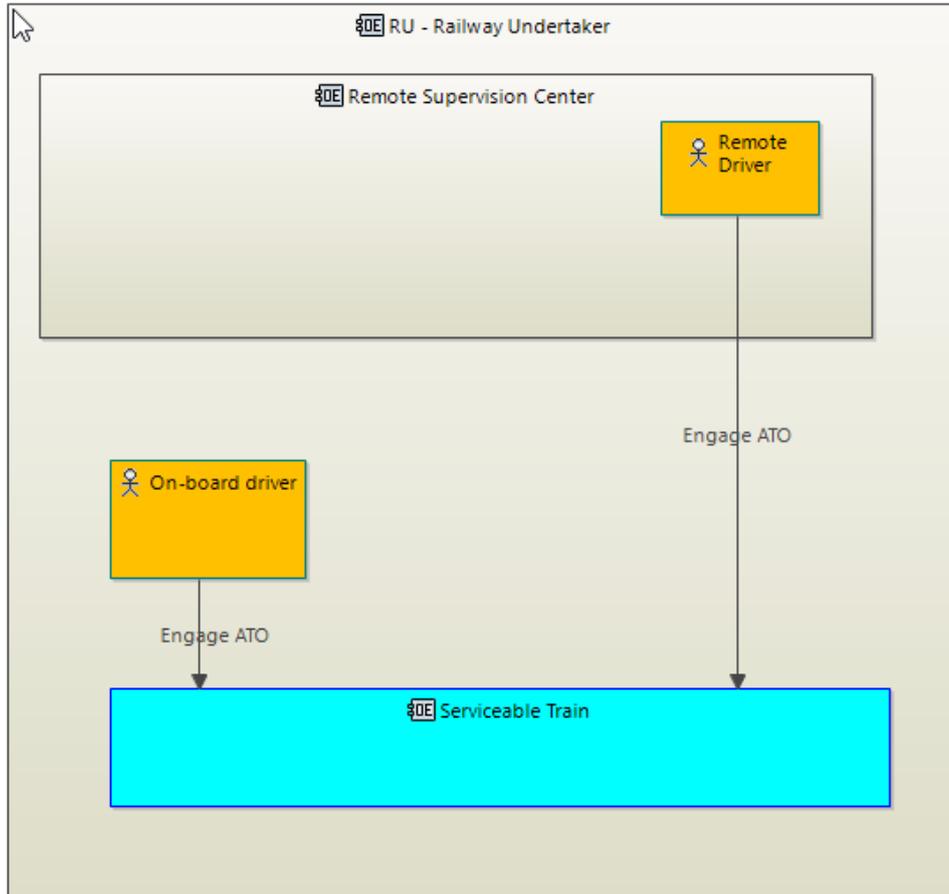


## 2.3 OPERATIONAL TECHNICAL ACTORS

Within geographically large systems such as the railway system as a whole, the vehicles moving within the system shall be considered as operational actors. They interact through moving along the system with the railway tracks, with passengers as they host them, with drivers who control them.

For WP5, the train is a key actor at the center of all things. It is defined as such (see also considerations in next paragraph).

In next figure, the operational technical actor train interacts directly with remote drivers and on-board drivers.



Assets of the infrastructure are also operational actors, in that they influence the vehicles. For instance:

- Points/switches interact with the train by defining its path along the track.
- Traction energy system, down to their overhead lines or third rail, restrict specific train movements or lead to transitions in the power supply of the train when passing from one system into another.
- The track itself, although inactive sets by its geometry requirements on the train's motion, e.g., speed limitations to avoid accidents.
- Stations with facilities for passengers, goods and maintenance enable loading and unloading of passengers, personnel and goods and servicing of vehicles.

The infrastructure, however, is not the key focus of WP5 (see System Pillar for this). Hence, infrastructure elements are elicited only if needed by the use cases under considerations. In use-cases where the 'infrastructure-related' part of the use-case is not detailed the entities 'infrastructure', as a whole, or 'operations' can help abstract the sub-use-case.

The logical system 'Trackside automation system' may also help – see next paragraph.

## 2.4 LOGICAL SYSTEMS: SUPPORTING ENTITIES OR ACTORS

Strictly speaking, operational analysis should be done without consideration of automation systems – except maybe HMI, see next paragraph.

It appeared in the use case description praxis that, describing use cases completely without technical systems is not easy: a technician used to think along a pattern of technical components may describe use-cases in an easier way by referring to those components. Indeed, the operations scope of WP5 have already been supported by complex systems interacting with the operational actors for decades, blurring the border between system and process,

A pragmatism practice arose among authors:

*For each 'key operational actor', a unique technical system can be introduced, either mirroring an entity or an actor. As this technical system could be mapped univocally to its entity or actor, the work of getting rid of this technical system was considered too little value for too much work. In some cases, the use-case with this technical system was deemed easier to read.*

For the train, the onboard automation system (OAS) was introduced, as receiver of all possible automation functions associated to a train, from automatic driving, incl. raising or lowering pantographs, down to broadcasting information to passengers in a compartment.

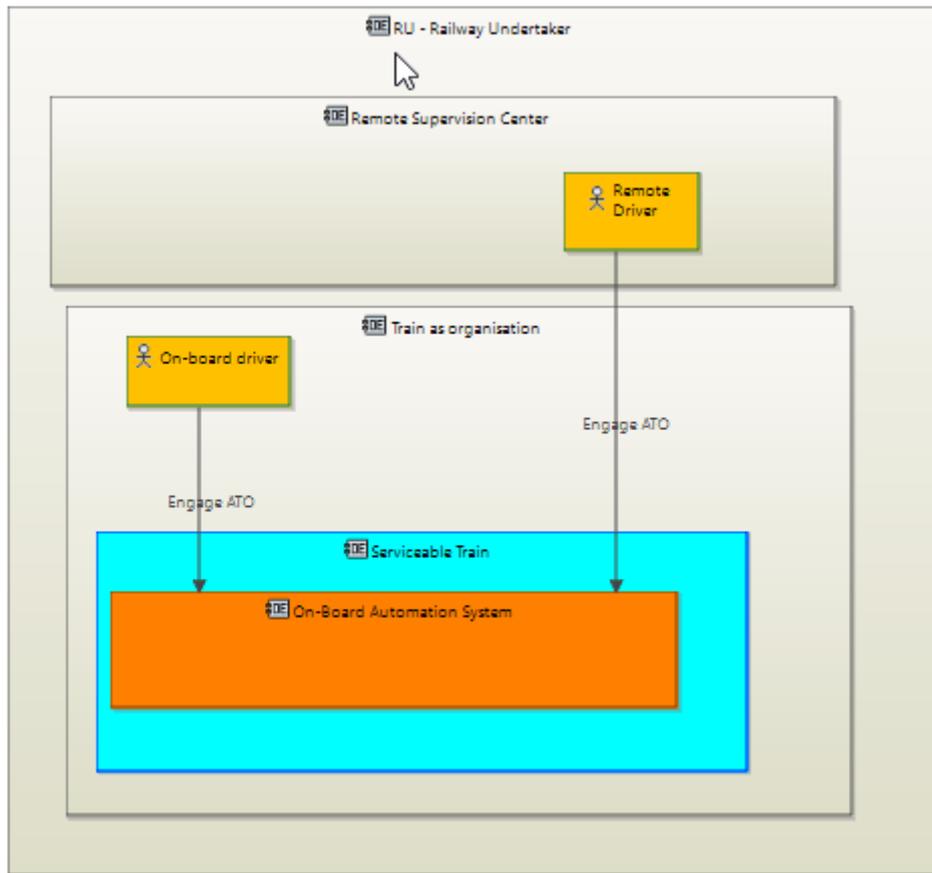
*If a technical system (logical component) is introduced, the operational entity or actor it represents shall be clarified.*

A special mention may be given to the Trackside Automation System (TAS). It corresponds very much to the 'system supporting the operational entity 'Operations': in many use-cases were TAS was taken as actor, the entity 'Operations' could have been taken. In others, where TAS actuates something, the operational technical actors could have been taken instead.

The added work of searching TAS everywhere, and replacing it by 'Operations' or a track element was deemed at best low added value: WP5 is about new topics of autonomous trains, operations are a rather high TRL. It may be counter-productive: for many use-case, OAS makes reading easier. For instance, in use-case UC.5.1.MK-OS-34, *Set low adhesion conditions*, the actor 'OAS' could be replaced by the technical operational actor 'train' without loss of information. For many a reader however, the use-case would lose some expressiveness.

*For template reasons, logical components are introduced in templates as actors. In current document, they are marked in this document as 'logical systems', which permits to differentiate from both X2Rail logical components and from true technical operational actors.*

In next figure, some 'On-board Automation System' supports the technical actor 'serviceable train'.



## 2.5 HMI

In general, it is satisfying in a ‘design independent’ operational analysis to define interactions between actors with some messaging at operational level. Introducing some HMI tends to define the process, i.e., restrict it to a technical solution. Once some HMI exists, it tends to introduce some costs or inertia in changes, which refrains from challenging the process. Therefore, some philosophies of operational analysis discourage considering HMI.

For instance, to describe the train take-over between remote and on-board driver, following sequence is enough:

1. “Remote driver: notifies the on-board driver with a control request”.
2. “On-board driver: notifies the remoter driver with a control acknowledgement”.

On the other hand, when some HMI is defined, describing those interaction by means of the HMI makes the description more real, easy to figure out, and illustrate the process. For instance, the following two examples mean the same. Example 2 is somehow more real:

1. “The driver notifies the train to brake in emergency”.
2. “The driver pushes his/her emergency braking button”.

For emerging processes, introducing an exemplary HMI can help represent the process. It can also help validate an ergonomic concept.

WP5 arbitrates between those contradictory tendencies according to the need: HMI components are accepted for WP5. A rather open guideline if defined for use-case redaction:

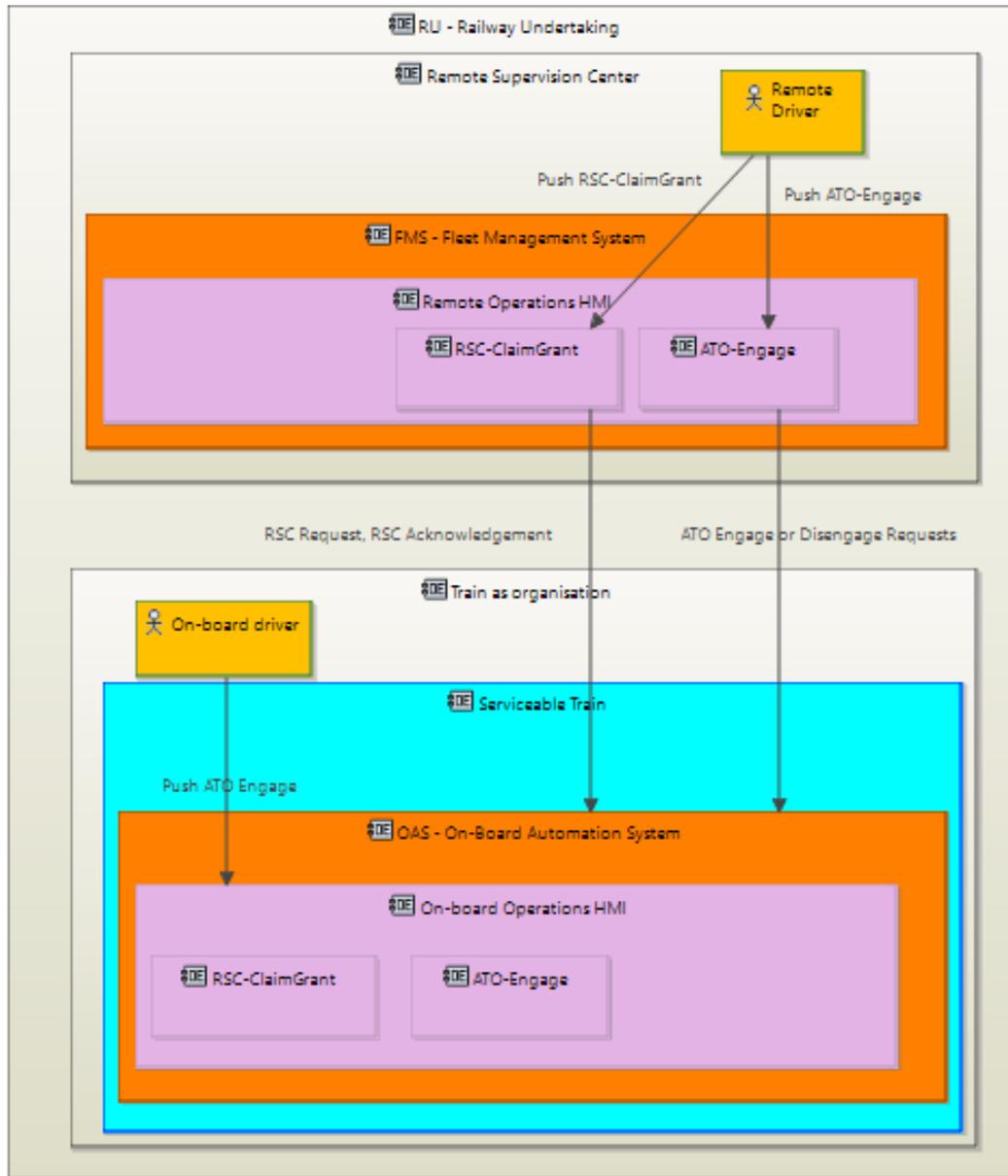
- *Authors may choose to ignore HMI components: 'The incident manager broadcasts to the passenger not to open doors' is precise enough without long explanations about the exact HMI used for this broadcast.*
- *Authors may choose to refer to HMI components. "The person in station pushes the emergency button on the nearest Platform Help Intercom" makes the scene more real than "the person in station calls for emergency".*
- *If some HMI component is present in a use-case, it shall be allocated to current document to one of the logical systems above, and to at least one human actor, allowed to implement the process the HMI supports.*

For instance,

- the Platform Help Intercom above is part of the Trackside Automation System. It is associated to the person in station (use-case Emergency On Platform). It may be associated to any other actor present on the platform, as virtually anybody is allowed to call for help.
- The remote operations interface for actors 'remote drivers' is derived from that for on-board drivers.

It is part of the Fleet Management System. It contains, as well as the on-board operations interface, a button 'RSC-ClaimGrant', proposed to validate an ergonomic concept of mastership hand-over of the train.

In next example, HMI are introduced for both on-board and remote drivers as part of the logical system they belong to.



## 2.6 LOGICAL COMPONENTS

Referring to more precise components than the logical systems, for instance on-board components UNISIG ATO, X2Rail PER or APM, ETMS ETCS-OB, focuses the use cases towards technical aspects, e.g., message exchanges, instead of presenting a synthesis of operations. Examples:

- “PER detects a person ahead of the train in the train's loading gauge. It communicates its position on track to APM. APM initiates an Emergency Braking Intervention.”

The above paragraph contains 3 sentences. It dissolves the message in noise. The below is preferred:

- On detection of a person ahead of the train in the train's loading gauge, the train initiates an Emergency Braking Intervention.

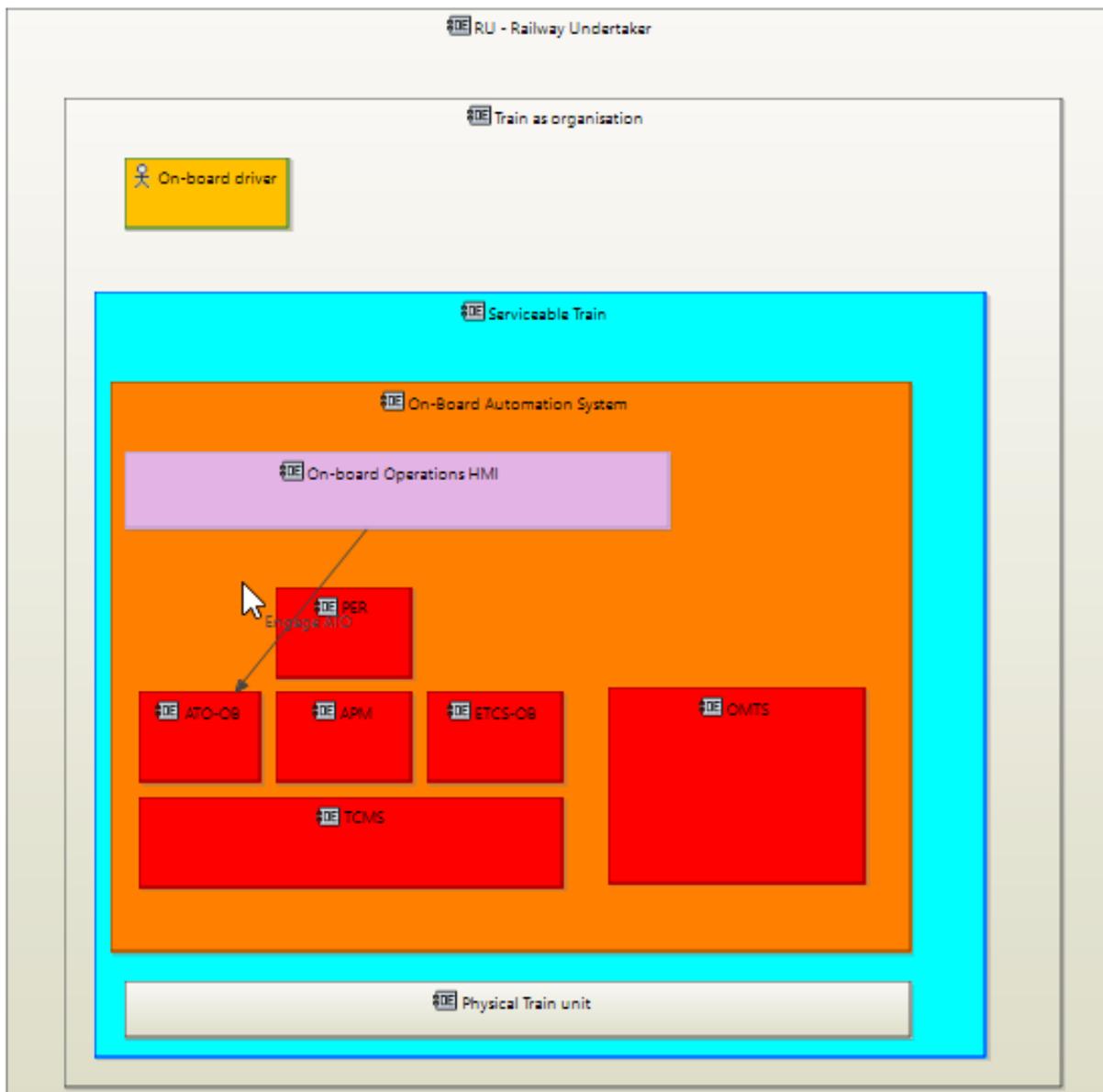
A similar guideline exists for trackside logical components (TMS, interlocking, etc.).

*The reference to logical components is discouraged.*

For instance, a use case describing remote control while obstacle collision avoidance does not work, or remote control while automatic driving does not work. In that case, those degraded modes can be defined by the lack of one of those components. For instance, use cases 'Remote control without ATO' or 'remote driving without PER'.

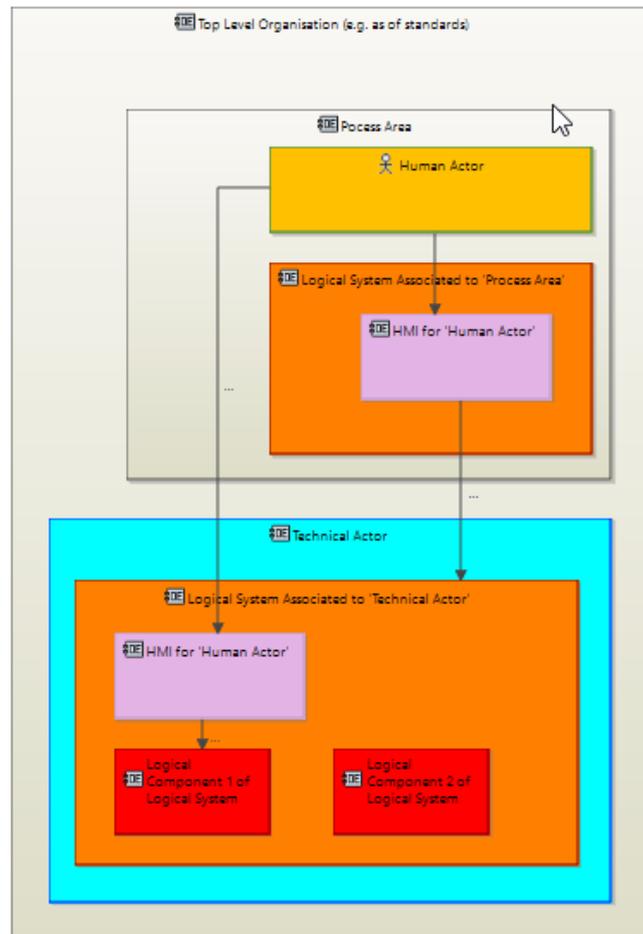
*An exception to discouraging logical components consists in use-case about degraded modes of the train automation system. In that case, components of the logical systems may be introduced as 'bundles of functions' not available.*

In next figures, logical components of the On-board Automation System are displayed in red:



## 2.7 SUMMARY: CONVENTION

The actors supporting WP5 use-cases can be roughly distributed over following categories, associated each with a colour code:



### Operational entities (implicit)

Operational entities are the organisational units / the process areas around the autonomous trains. They structure process areas, operational actors, or this document.

### Human operational actors (mandatory)

Human operational actors are roles in the system taken by humans, e.g., operations manager, RU Supervisor, on-board driver, remote drivers.

In former figure, two roles are introduced: railway undertaking Supervisor and Remote Driver, both attached to the remote supervision centre.

### Technical operational actors (recommended)

Technical operational actors are the technical components taking part of the railway system and its logistic process, e.g., trains, switches, level-crossings, track-segments, catenary sections.

### **Logical systems**

Logical systems introduced to address the automation associated with one entity or technical actor. Logical systems are not per se necessary in WP5. They are welcome when helping a use-case author specify his/her use-case.

Their name ends with 'System' (Trackside automation system, Onboard Automation System, Fleet Management System, ...)

### **Human Machine Interface (optional)**

Components of the logical systems dedicated to interfacing with human actors. Authors may choose to ignore them (operational analysis by the book) or introduce them to make the use-case description more real, or introduce some ergonomics concept.

### **Logical components**

The reference to logical components is discouraged. An exception consists in use-cases about degraded modes of the train automation system. In that case, components of the logical systems may be introduced as 'bundles of functions' not available.

### **3 ACTORS UNDER THE LIGHT OF GOA**

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Railway is a system of systems. None of the systems can be operated in isolation. When describing the operational use cases with different operational actors, it is helpful to see the role of each actor at a whole railway architecture rather than focusing on a specific organisation.

Some functions taken by human actors in GoA1 operation as of today are expected to be automated by systems in GoA2 or GoA3 or GoA4 operations in the near future. Some functions automated in GoA1 operation might be upgraded with additional features in GoA2 or GoA3 or GoA4 operation in the near future.

As an introduction to the actors in this document, current chapter shows the migration of human actors and systems from GoA1 to GoA4.

This storyline has been made courtesy of the X2Rail-4 project, derived from their Operational Concepts document. It is comparable in between X2Rail-4 project and WP5 project that might be helpful for any future work to compare the definition of actors.

In the figures below, the interfaces and system boxes are described using the following logic:

- Grey solid line indicate interface between systems.
- Green dashed line indicate interface involving a human.
- Grey and red dashed line indicate optional interfaces.
- Red colour indicates the evolution of ERTMS/ATO.

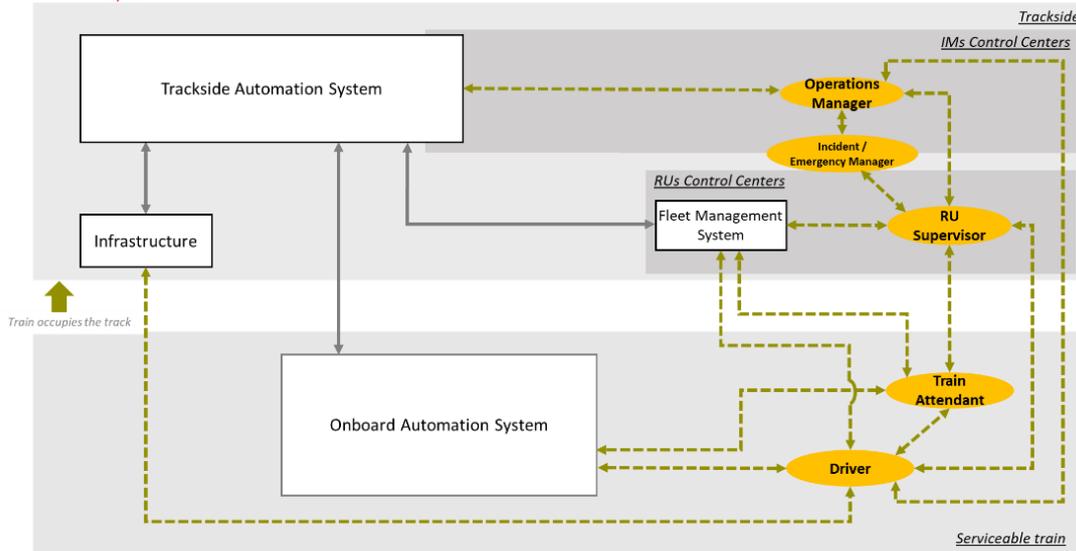
#### **3.1 GoA1**

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In GoA1, the driver is responsible for train movement following the indications from Onboard Automation System (OAS), observing infrastructure assets (e.g., trackside signals), using the timetable information and route information provided by the Traffic Automation System (TAS) located in the IM control centre. TMS supports dispatcher and signaller operations such as traffic planning, traffic regulation or route setting. The driver and train attendant (only for passenger train) execute the mission provided by a Fleet Management system (FMS) located in the RU control centre. That is to say, the driver in GoA1 integrates the authorised information from the IM and from RU and responsible for the train. When abnormal situation happens, all (human) actors work together to return operations to normal conditions while avoiding the risk of a further degraded situation or even accidents.

The major automation revolution in GoA1 is the introduction of ATP-trackside system into TAS and ATP-onboard system into OAS. This revolution in GoA1 is safety relevant.

GoA1/2 Actors in WP5



### 3.2 GoA2

In GoA2, OAS automatically drives the train, through control of traction and braking, including but not limited to accurate stopping at specified stopping positions using information provided by TAS. In normal operation, OAS is optimising for train movement, while the driver is still responsible for train movement by engaging and disengaging GoA2 automated driving function. The driver supervises overall train operations as well as the track ahead for obstacles and controls the doors. In abnormal situation, the driver is responsible for the train.

Based on GoA1, the major automation revolution in GoA2 is the introduction of ATO-trackside system into TAS and ATO-onboard system into OAS. The main task in GoA2 is to automate and optimise the train speed control.

There is no difference in the high-level system architecture in between GoA1 and GoA2 when using the WP5 actors OAS and TAS.

### 3.3 GoA3

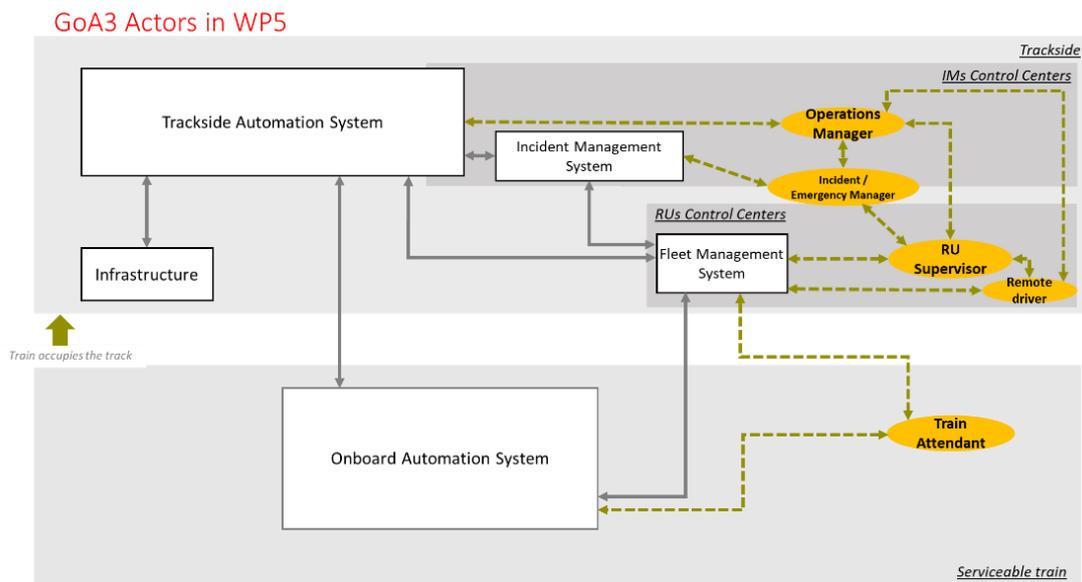
GoA3 is defined as driverless train operations where the train operates without a driver but with personnel onboard supervising operations, engaging and disengaging automated driving as well as acting in case of degraded or emergency situations.

- The supervision and control of doors can be partially or fully allocated to the system or manually performed by the on-board personnel. Additionally, to automate train movement according to the journey given by IM, other daily tasks given by RUs such as train configurations, train preparations, shunting, coupling, decoupling, and cleaning, are expected to be automated.
- The personnel on-board or train attendant is responsible to supervise operations and act in case of a degraded or emergency situation.

In normal situation, OAS works together with TAS, FMS to further improve the efficiency of overall train operation. In abnormal situation, OAS is responsible to react and take decisions, as well as to recognise and report to TAS, FMS and the Incident Management System (IMS). Based on the report, human actors work together to avoid accidents and reduce the risk. In degraded situation, remote driving is expected when the ATO function in OAS fails.

Today many railways have their own definition and scope of IMS to prevent and react on incidents and accidents. The IMS as conceptualised here would align the solutions from both IM and RU. IMS could be allocated to the IM control centre, but this does not exclude that IMS can implement on part of RU as well.

Based on GoA1 and GoA2, the major automation revolution in GoA3 is the further development of ATO related sub-systems in TAS and OAS, and the bidirectional communication between TAS and FMS. The main task starting from GoA3, is to further integrate the automation systems in between IM and RU as a whole. The revolution in GoA3 is safety relevant.

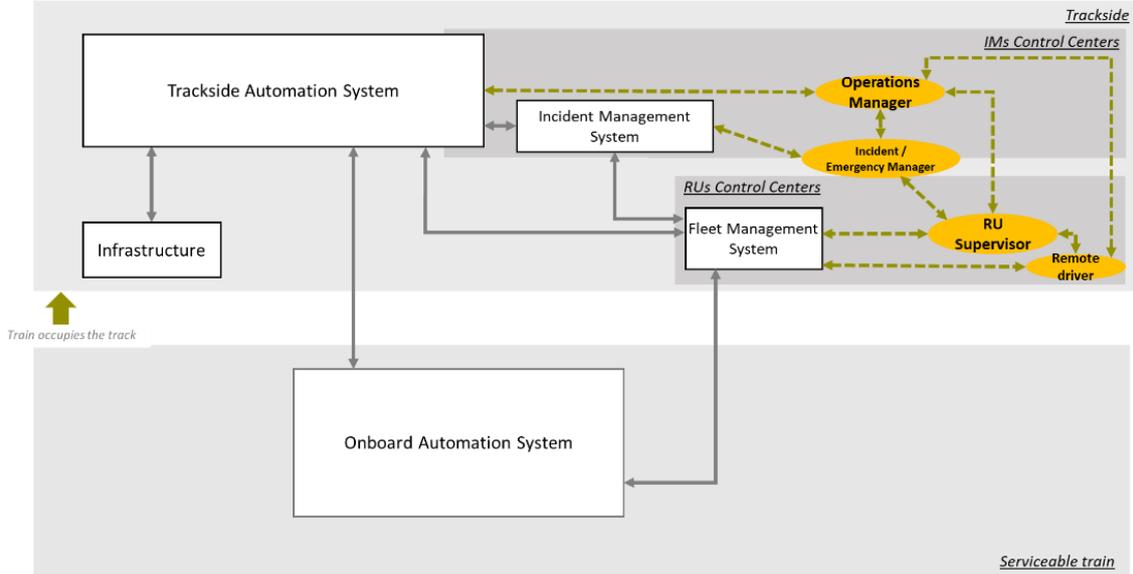


### 3.4 GoA4

In GoA4, both train driver and train attendant are absent. There shall be no major technical difference in between GoA3 and GoA4, except for some certain tasks such as door management allocated to on-board personnel (e.g., train attendant).

The major automation revolution in GoA4 should be the same as GoA3. That is why sometimes it is named together as GoA3/4. The revolution in GoA4 is safety relevant.

GoA4 Actors in WP5



### 3.4.1 Actor mapping in between X2Rail-4 and WP5

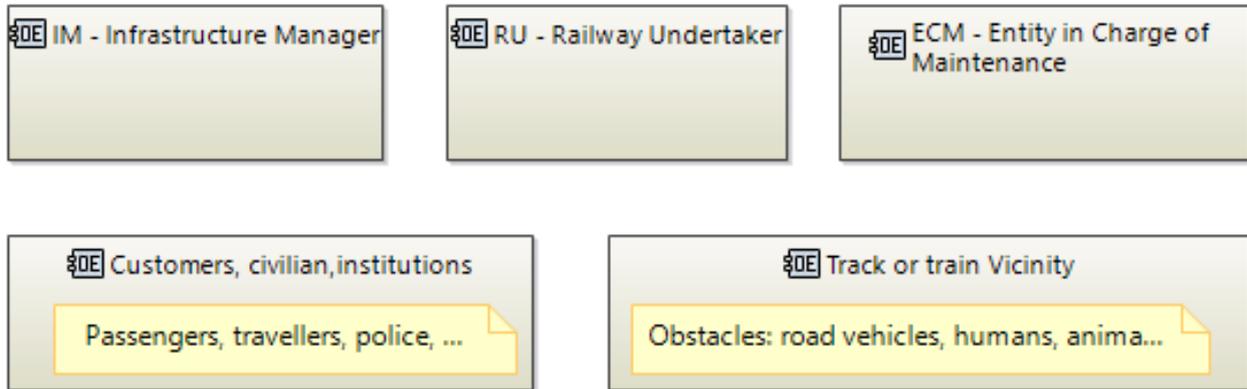
Since many use cases in WP5 have reference to the X2Rail-4 use cases. It would be helpful to make a mapping for better understanding both works and efficient any future updates.

A proposed mapping in between logical system is below:

Mapping WP5 terms in X2R4	OAS	TAS	FMS	IMS
GoA1	ATP-OB	ATP-TS	TM	ISM
GoA2	ATP-OB + ATO-OB	ATP-TS + ATO-TS	TM	ISM
GoA3/4	ATP-OB + ATO-OB + PER + APM + REP	ATP-TS + ATO-TS	TM	ISM

## 4 OVERVIEW

This chapter introduces the high-level organization units of the railway system groups introduced to gather unexpected or associated roles.



<b>IM - Infrastructure Manager</b>
Defined by EU Directive 2012/34 as ‘any body or firm responsible for the operation, maintenance, and renewal of railway infrastructure on a network, as well as responsible for participating in its development as determined by the Member State within the framework of its general policy on development and financing of infrastructure.’
Source: X2Rail-4
Kind: Human operational actor

<b>RU - Railway undertaking</b>
Defined by EU Directive 2012/34 as ‘Any public or private undertaking licensed according to this Directive, the principal business of which is to provide services for the transport of goods and/or passengers by rail with a requirement that the undertaking ensure traction; this also includes undertakings which provide traction only.’
Source: X2Rail-4
Kind: Operational entity

<b>ECM - Entity in Charge of Maintenance</b>
Defined by EU directive 2016/798, the Entity in Charge of Maintenance 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.

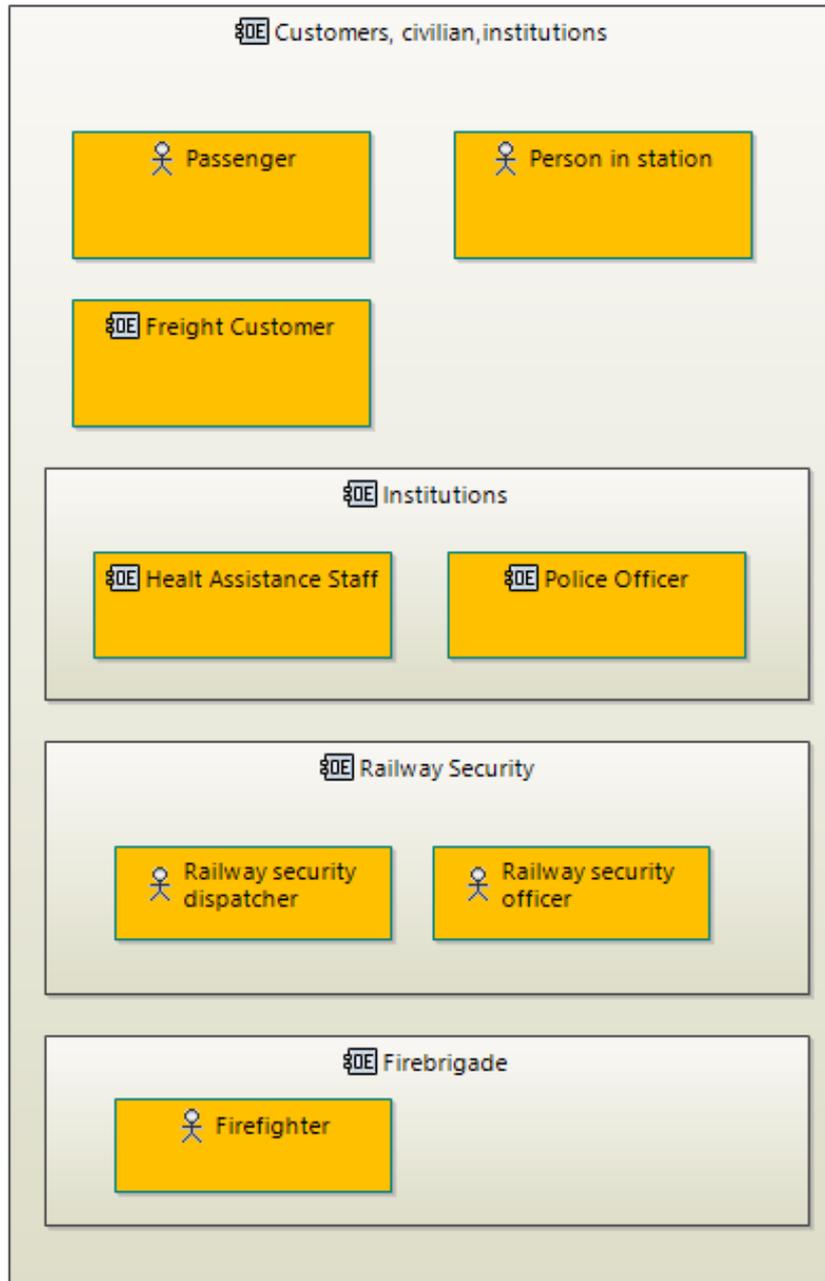
Source: X2Rail
Kind: Operational entity

<b>Customers, civilians and institutions</b>
This entity groups human actors and organizations <ul style="list-style-type: none"><li>- interacting with the railway system, while not being part of it themselves (passenger, police forces, ...).</li><li>- that may be part of either IM, RU, or even an own institution and for which WP5 did not need a clear attribution: railway security, fire brigade.</li></ul>
Source: WP5
Kind: Operational entity

## 5 CUSTOMERS, CIVILIANS, INSTITUTIONS

This chapter groups human actors and organizations

- interacting with the railway system, while not being part of it themselves (passenger, police forces, ...).
- that may be part of either IM, RU, or even an own institution and for which WP5 did not need a clear attribution: railway security, fire brigade.



## 6 MEMBERS OF THE GENERAL PUBLIC

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<b>Passenger</b>
<p>The passenger represents the persons using the railway system for travelling on-board passenger trains and embarking or disembarking at stations.</p> <p>The same person may be modelled as a 'person in station' after disembarking.</p>
Source: X2Rail
Kind: Human operational actor

<b>Person in station</b>
<p>A person in station represents a person of the general public on a platform or elsewhere in a station, not involved in the undertakings of infrastructure management or railway undertaking and neither boarding nor disembarking during a use-case: this would be a passenger.</p> <p>According to this definition, the person in station may change role and be named 'passenger' while starting to embark.</p>
Source: R2DATO
Kind: Human operational actor

<b>CFR - Certified First responder</b>
<p>Member of the general public or railway profession relying on first aid skills.</p> <p>While another human actor needs aid, this person may be involved in the assistance processes before Emergency Medical Technician reach.</p>
Source: R2DATO
Kind: Human operational actor

## 6.1 CUSTOMERS

<b>Freight Customer</b>
The Freight Customer is the person in charge of the purchasing of the transport contract. The Freight Customer provides the freight characteristics (weight, type...) and the schedule request to the RU Supervisor.
Source: X2Rail-4
Kind: Human operational actor

## 6.2 RAILWAY SECURITY

<b>Railway Security</b>
Organization supporting the security of travellers, members of the public, railway professionals, premises, and vehicles incl. public furniture in vehicles and along the railway network.  The railway security acts locally by means of railway security officers remotely coordinated by railway security dispatchers.  They may also secure safety-related processes (medical aid, fire-fighters). They may be helped by police officers when the limitation of their status requires it (apprehending individuals).
Source: R2DATO WP5
Kind: Operational entity

<b>Railway Security dispatcher</b>
An employee of the railway security, the railway security dispatcher is responsible for the coordination of railway security officers, typically their allocation on incidents. May contract Police forces.
Source: R2DATO WP5
Kind: Human operational actor

<b>Railway Security officer</b>
An employee of the infrastructure manager responsible for helping person in stations and managing deviances by public in the infrastructure’s premises. May be helped by police officers.
Source: R2DATO WP5
Kind: Human operational actor

### 6.3 FIRE BRIGADES

<b>Fire brigades</b>
Safety organization to avert hazards to people and animals, e.g., life-threatening. In intervenes mainly in terms of fire prevention and suppression but also hazards due to floods, electricity, hazardous material, or other events. In the real world, fire brigades may be institutional, local or stately, or be some dedicated organisation inside IM or RU. Keep for instance in mind SBB’s dedicated fire extinguishing trains. As this aspect is not important for R2DATO, all fire brigades are defined for the project independently of IM and RU.
Source: R2DATO
Kind: Operational entity (optional)

<b>Firefighters</b>
Firefighters are the human actors making up the fire brigades.
Source: R2DATO
Kind: Human operational actor

## 6.4 OTHER INSTITUTIONS

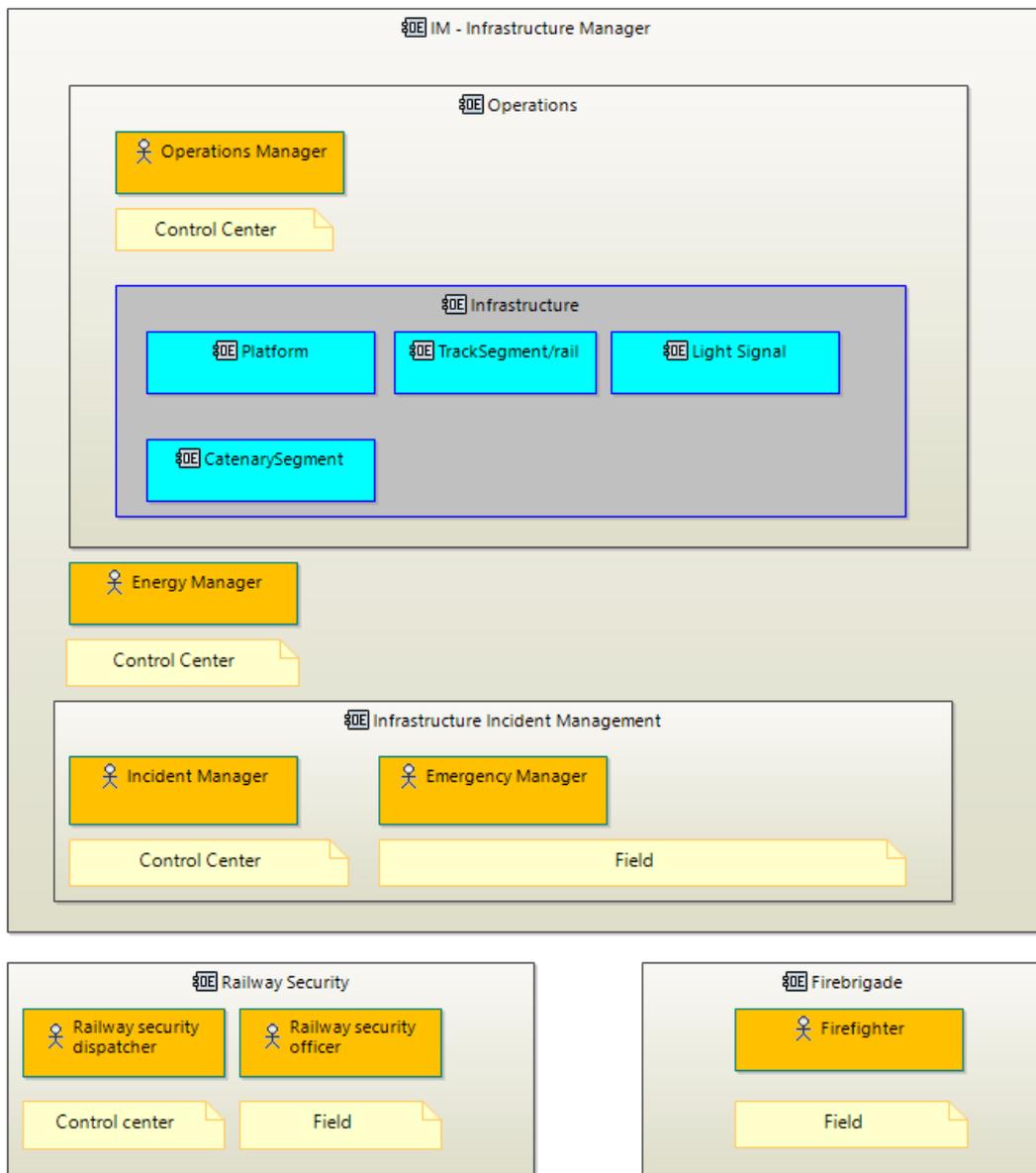
<b>Police officer(s)</b>
<p>In the R2DATO context, police officer(s) are members of police implied in railway processes when public security authorities are needed. Important in this definition is that the police officer(s) are not part of the railway system, unlike security officers.</p> <p>A single police institution may fulfil several roles (criminal, policing, customs). According to the situation, a use-case may require one or more officers.</p> <p>Current actor covers all roles, independently of local institutions and their lawful responsibilities towards railways. The use-cases do not specify how many officers are required.</p>
Source: R2DATO
Kind: Human operational actor

<b>Emergency Medical Technicians</b>
<p>Medical personnel dispatched in infrastructure premises or trains to treat sick or injured persons or to notifying fatalities.</p>
Source: R2DATO
Kind: Human operational actor

## 7 INFRASTRUCTURE MANAGER

The infrastructure manager is the organization managing the infrastructure. It is composed of process areas operations and incident management. Inherited from some X2Rail-4 processes, an energy manager is attached to it.

The infrastructure manager is very likely to comprise its own railway security organization. In some countries, railway undertakings also have some railway security. R2DATO WP5 use-cases did not need to differentiate between RU and IM security officers. Therefore, the railway security is managed in an operational entity of its own, shared by both in the context of the project –See chapter ‘Customers, civilians, institutions’. Fire brigades are considered similarly.



## 7.1 ORGANISATIONS AND HUMAN ACTORS

### RNO - Railway Network Operations

The Railway Network Operations process area, sometimes shortened 'Operations' is the context is clear, is in charge of regulating the traffic on the infrastructure. It is supported by the Trackside Automation System.

Source: X2Rail

Kind: Operational entity

### OM - Operations Manager

The Operations Manager represents a person responsible for the railway operation of the System in a given geographic area.

The operations manager synthesized classic roles 'dispatcher' and 'signaler'.

This person is part of the Infrastructure Management entity.

Therefore, if the Operations Manager is employed by a railway undertaking, this railway undertaking acts on behalf of the infrastructure manager and is considered having replaced the role of the infrastructure manager in this case.

The Operations Manager supervises the normal operation performed automatically by Traffic Management and manages specific actions that cannot be executed automatically.

Source: X2Rail

Kind: Human operational actor

### EM - Emergency Manager

This person is part of the Infrastructure Management entity, acting in the Incident management process area.

Like the incident manager, the Emergency Manager is a person dedicated to the solving of incidents. Unlike Emergency managers, Incident managers act from the field. They may need some delay until they reach the location of an incident.

Their task may comprise all those of an incident manager, plus non-automated emergency functions which require local human actions.

<p>Like Incident manager, Emergency managers interface with Operations managers all along the life-cycle of the incident to help optimize the traffic in spite of degraded conditions while enabling the safe deployment of personal and assets along the track.</p> <p>The Emergency Manager can also act remotely as a pedestrian remote driver (x2rail).</p>
Source: X2Rail
Kind: Human operational actor

<p><b>IIM - Infrastructure Incident Management</b></p>
<p>The Infrastructure's Incident management is the process area dedicated to the solving of incidents during operations.</p> <p>It comprises incident managers (coordination/remote), emergency manager (coordination/field).</p> <p>Incident and Prevention Management is the organization, incl. Its building, IT infrastructure and Incident Solving Managers, that coordinates resolution of non-regular situations on the track – trespassers, broken components, ...</p> <ul style="list-style-type: none"> <li>• An incident is monitored and managed during its whole lifecycle from the first recognition to the resolution.</li> <li>• Specified routines are created to resolve Non-Regular Situations with a minimal impact on railway operation.</li> <li>• Planned routines are executed and assisting entities coordinated.</li> <li>• Solving processes are likely to be supported by external entities (fire brigade, emergency doctors, police)</li> <li>• Solving processes are aligned and prioritized.</li> </ul> <p>It relies strongly on railway security and is likely to imply institutional actors (police, health assistance, fire brigades, civil protection, water and waste management, armed forces, maritime institutions ...).</p> <p>Incident Prevention Management predicts for operations management the geographical, temporal and resource related impact of the incidents they solve on scheduled railway operation.</p> <p>It is supported by the Incident Management System.</p>
Source: R2DATO WP5
Kind: Operational entity

<p><b>IIM - Incident manager</b></p>
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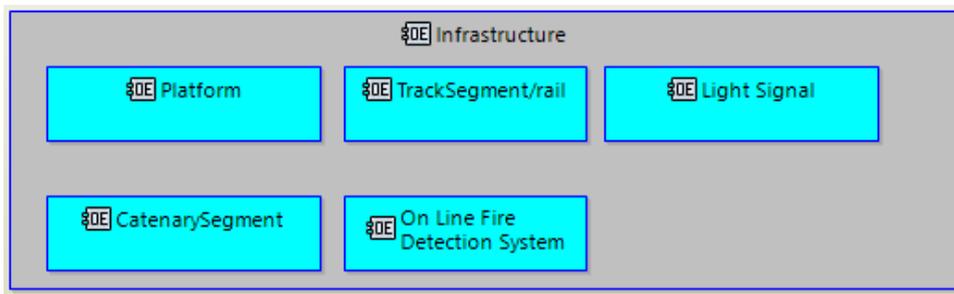
<p>This person is part of the Infrastructure Management entity, acting in the Incident management process area. The Incident Manager is a person dedicated to the solving of incidents, defined as unexpected events impeding operations. Unlike Emergency managers, Incident managers act from a control center.</p> <p>Their task routinely comprises contracting RU-incident management, Emergency Managers, railway security acting for the infrastructure manager, police force, fire brigade, health assistance staff and sometimes other miscellaneous emergency services such as water and waste management, armed forces, maritime institutions, civil engineering.</p> <p>Incident managers interfaces with Operations managers all along the life-cycle of the incident to help optimize the traffic in spite of degraded conditions while enabling the safe deployment of personal and assets along the track.</p>
<p>Source: R2DATO WP5</p>
<p>Kind: Human operational actor</p>

<p><b>IEM - Emergency Manager</b></p>
<p>This person is part of the Infrastructure Management entity, acting in the Incident management process area.</p> <p>Like the incident manager, the Emergency Manager is a person dedicated to the solving of incidents. Unlike Emergency managers, Incident managers act from the field. They may need some delay until they reach the location of an incident.</p> <p>Their task may comprise all those of an incident manager, plus non-automated emergency functions which require local human actions.</p> <p>Like Incident managers, Emergency managers interface with Operations managers all along the life-cycle of the incident to help optimize the traffic in spite of degraded conditions while enabling the safe deployment of personal and assets along the track.</p> <p>The Emergency Manager can also act remotely as a pedestrian remote driver (X2Rail).</p>
<p>Source: X2Rail</p>
<p>Kind: Human operational actor</p>

<p><b>EM - Energy Manager</b></p>
<p>The Energy Manager manages from a control center the electrical power distribution along the track, to overhead lines and third rails.</p>

<p>The control center is linked to remote terminal units (RTUs) connected to the master PLCs in the substations, as well as to the circuit breakers and sectioners along the contact line. .</p> <p>This manager is part of the Infrastructure Management and manages from a control center the electrical power distribution along the track, to overhead lines and third rails. .</p>
Source: X2Rail
Kind: Human operational actor

## 7.2 TECHNICAL ACTORS



<b>Infrastructure</b>
The sum of all technical actors managed by the infrastructure manager. This is a technical entity rather than an actor.
Source: R2DATO WP5
Kind: Technical operational actor (optional)

<b>Light Signal</b>
The 'Light Signal' is an optical indicator that transmits information to train drivers.
Source: X2Rail
Kind: Technical operational actor

<b>Platform</b>
Platforms are the start and end points of train runs. At platforms, passengers' step in or step out of the train. Platforms also interact with trains in motion: when a train drives along a platform, the platform may set speed limits.
Source: R2DATO WP5

Kind: Technical operational actor
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<b>Track Segment</b>
Track segments
Source: R2DATO WP5
Kind: Technical operational actor

<b>Catenary Segment</b>
Segment of the overhead line or of the third rail, associated to some electrical power distribution. May be a full segment with constant electrical power distribution or a short part, considered in a use-case because it is damaged.
Source: R2DATO WP5, S-125.
Kind: Technical operational actor

<b>On Line Fire Detection System</b>
A Fire Detection System monitors some track area for fire appearance. If Some fire occurs, it reports the fire to the Incident Solving Manager responsible for the area it monitors.
Source: R2DATO WP5
Kind: Technical operational actor (optional)

### 7.3 LOGICAL SYSTEMS

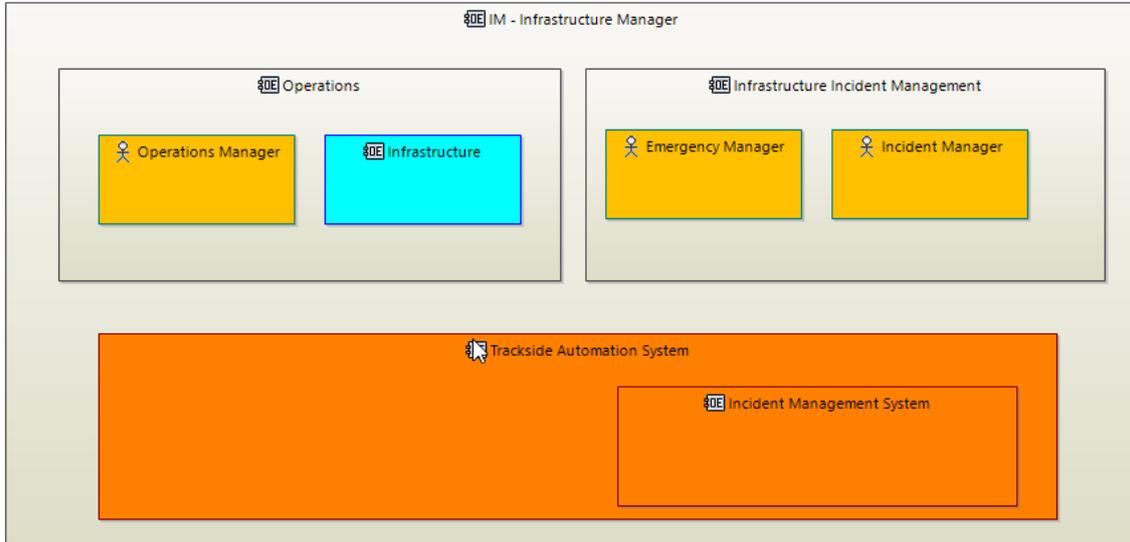
The Trackside Automation System supports the infrastructure manager processes. One of its components, the incident management system supports only the process area 'incident management'.

As the Incident Management System is emerging (introduced by X2Rail as Incident Solving Manager (ISM)), a debate animated R2DATO WP5 whether IMS should be part of OAS or not:

- As a new system, it does not have to be considered part of OAS (unlike TMS, Ixl, ...): incident management is a new process area under the scope of automation.
- As a system specifically important for the autonomous train (consolidation of non-regular conditions, see definition), this system deserves a special highlighting for R2DATO-WP5.

Decision was made to:

- make it part of OAS, I.e., strictly speaking a logical component.
- Promote it a logical system to emphasize that it is not discouraged in the use-cases.



### IMS - Incident Management System

The incident management system is the system supporting the process area Infrastructure Incident Management. As such, it covers the Incident manager's workflow aspects related to incidents.

The Infrastructure Incident management is the process area dedicated to the solving of incidents during operations. It comprises incident managers (coordination/remote), emergency manager (coordination/field).

Incident Management System is also system trackside responsible for automated detection and handling of non-regular situations (incidents/accidents/failures) in railway operation on the trackside.

Detection means e.g.,

- Falling object detectors at tunnel exits, road overpasses, in mountain areas.
- Fire detectors/Gas detectors e.g., installed in some tunnels to detect fires.
- Gas detectors in tunnels, detecting high concentrations of CO and NOx generated by fire or the passing diesel trains.
- Air flow detectors in tunnels, verifying that the air in tunnel remains suitable for humans.
- Lateral-wind detectors in some windy locations of the network generate temporary speed restrictions if local winds jeopardize vehicle stability.
- Detectors of hot grease boxes, brake discs and wheels.
- Detectors of dynamic behaviour of pantographs.  
They are based on measuring elevation of the contact line, if the value is out of range, a signal is sent to implement appropriate measures (which could include stopping the train).
- Vertical impact detectors on the track (there are just a few installed). They detect the status of the wheels as well as the weights, so they report anomalies.
- Obstacle detectors in level crossings based on cameras.
- Computer vision system to monitor landslides in embankments installed in a few particularly risky locations of the network.
- Distributed Acoustic Sensing (DAS) for detection of earthquakes and of rocks/obstacles falling into the track, based on the use of the existing optic fibre.
- CCTVs to monitor abnormal situations e.g., people crossing from one platform to the other through the track area.

The automated scope also includes the response to non-regular situations and their solving:

- Consolidate non-regular situations detected by several track-side sensors, e.g., pedestrian detection by several CCTV sensors, following along several sensor.
- Consolidate non-regular situation detected by train units in the network.
- Declare clearance of a non-regular situation (several trains could not detect a trespasser, flood solved).

<p>The system proposes automatic handling, relays alarms to the relevant stakeholders, or propose them actions depending on the nature of the non-regular situation:</p> <ul style="list-style-type: none"> <li>• Apply temporary speed limits (flood, fallen objects, wind sensors)</li> <li>• Report non-regular situation</li> </ul>
<p>Source: corresponds to X2Rail's X2Rail-4 v0.1: Incident and Prevention Management - Incident Solving Manager (IPM-ISM)</p>
<p>Kind: Logical System (optional)</p>

<p><b>Trackside Automation System</b></p>
<p>The Trackside Automation System owned by the infrastructure manager provides all the track side automation functions from scheduling a train run down to setting routes and points in the right direction and issuing movement authorities for each train run.</p>
<p>Source: R2DATO WP5</p>
<p>Kind: Logical systems</p>

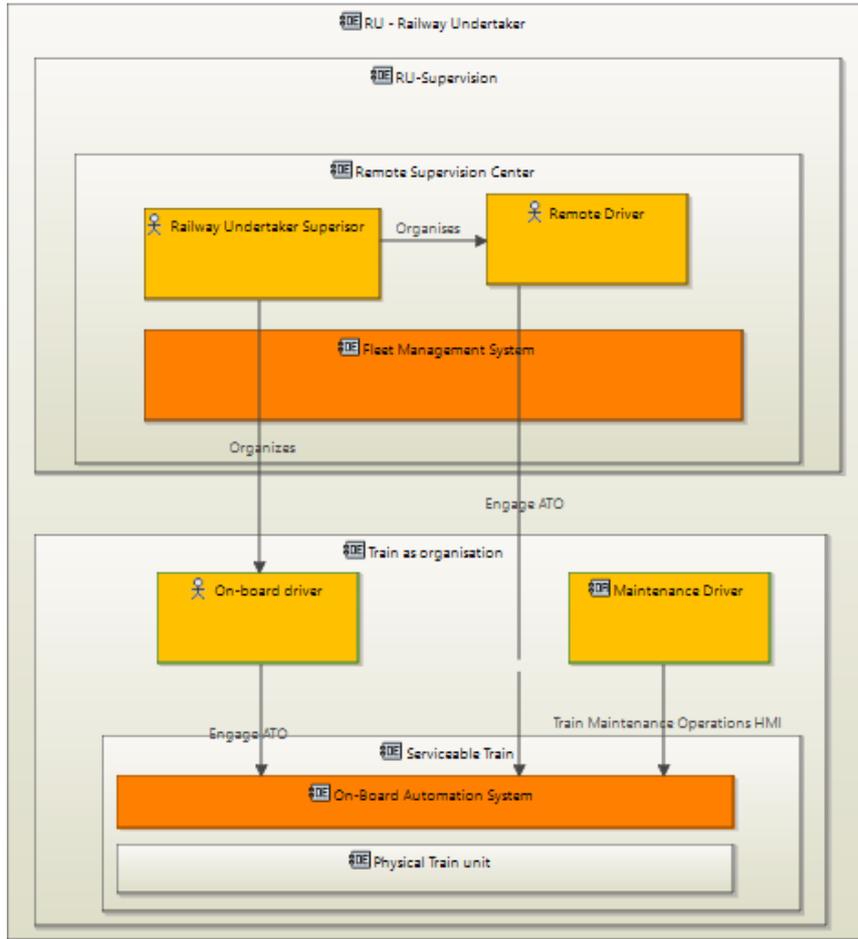
## 7.4 HUMAN MACHINE INTERFACES

Human Machine Interfaces (HMI) are not operational actors. They do provide, however, the means of the communications between actors. Therefore, some HMI are provided, incl. the interaction they provide.

<p><b>Platform Help Intercom</b></p>
<p>A system provided for pedestrians on a platform which can be used to inform infrastructure management that some occurrence on the platform requires attention.</p> <p>The system provides following capabilities:</p> <ul style="list-style-type: none"> <li>• Emergency request: typically, a push button. The pedestrian asks for support in an emergency case: fire, injured or unconscious person on the platform, person trapped by a train door, etc.,</li> <li>• Information request: a request without the emergency nature above.</li> <li>• Voice exchange: microphone and loudspeaker.</li> </ul>
<p>In R2DATO, Emergency requests are sent to the Incident Solving Manager responsible for the station, while Information requests are sent to the station management.</p>
<p>Source: R2DATO WP5</p>
<p>Kind: HMI</p>



## 8 RAILWAY UNDERTAKING



### 8.1 ORGANISATIONS AND HUMAN ACTORS

#### Remote Supervision and Control Center

Remote Supervision and Control Center form a part of railway undertaking operations, comprising an organization, facility, personal, and IT environment hosting the remote operations of trains.

Source: TAURO

Kind: Operational entity

#### RUS - Railway Undertaking Supervisor

The Railway Undertaking Supervisor represents an employee of the railway undertaking, coordinating the operations of the railway undertaking:

<ul style="list-style-type: none"> <li>- Allocates train consists to train unit runs to fulfill transport demand.</li> <li>- Allocates on-board and remote drivers to train units</li> <li>- Attends train passengers             <ul style="list-style-type: none"> <li>- Acts as incident managers for railway undertakings. Allocates train consists to train unit runs in order to fulfil transport demand.</li> <li>- Allocates on-board and remote drivers to train units.</li> <li>- Attends train passengers.</li> <li>- Acts as an incident manager for the RU.</li> </ul> </li> </ul>
Source: X2Rail
Kind: Human operational actor

The word “driver”, when used in a R2DATO use-cases is either clear from its context, or the on-board driver defined below. In a remote control-related use-case, it should not be used alone.

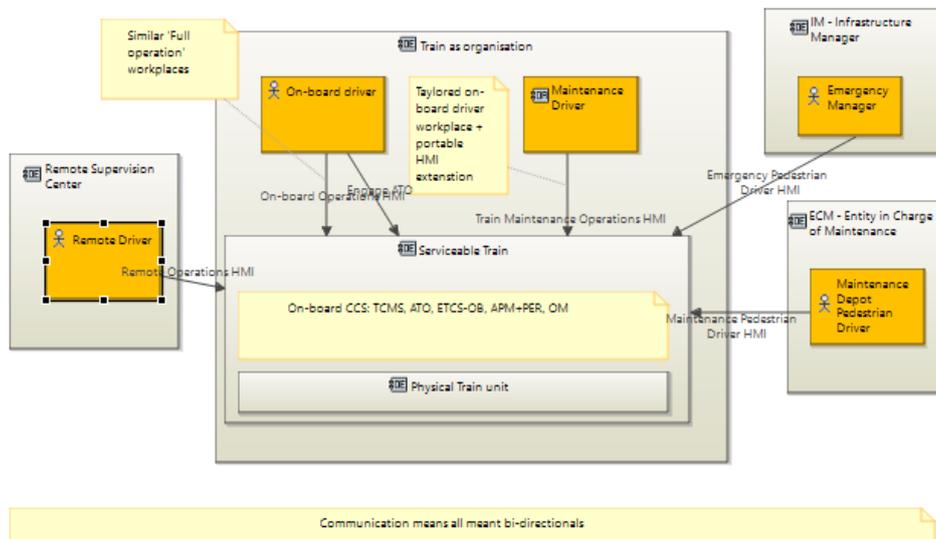
<b>On-board driver</b>
<p>The on-board driver of a train drives a train from its physical driver’s compartment.</p> <p>He / she may be driving at journey level (GoA2: engage ATO) or manually (GoA1: manage doors, traction and braking chains) with more or less assistance (automatically raise/lower pantographs, automatic coupling, ...).</p> <p>He/she is part of a railway undertaking.</p>
Source: R2DATO WP5.4, split from X2Rail
Kind: Human operational actor

<b>Remote driver</b>
<p>Remote driver is part of the Railway Undertaking and supervises and controls the train remotely and drives the train when required from a remote workplace.</p>
Source: R2DATO WP5.4, split from X2Rail
Kind: Human operational actor

<b>REMT - Remote Emergency Medical Technician</b>
A medical professional capable to provide remote assistance to persons in a train.  This also means giving guidance to a person helping another.  He/she is part of a railway undertaking.
Source: R2DATO WP5.4, split from X2Rail
Kind: Human operational actor

## 8.2 TECHNICAL ACTORS

The word train, when used in a R2DATO use-cases is means the serviceable train defined below. In case of ambiguity, the author is expected to use one of the definitions in this section.



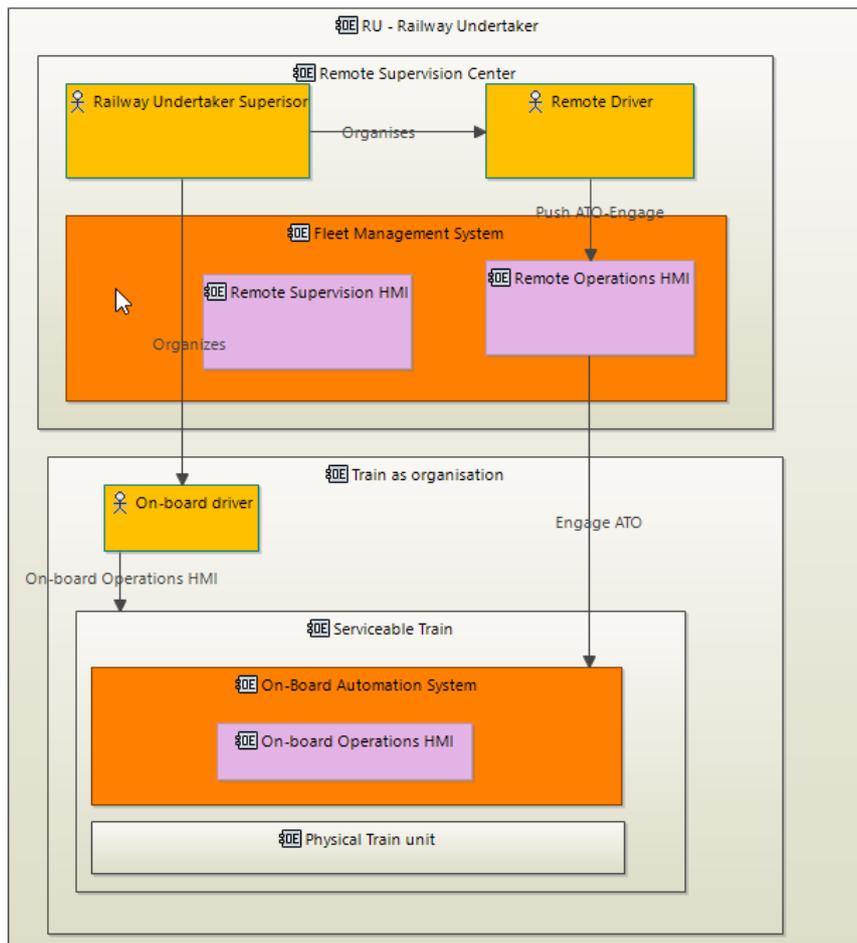
<b>Physical Train Unit</b>
The Physical Train Unit conveys passengers or freight to its destination. The Physical Train Unit functions come from EN 15380-4 (5.3.1 and 5.3.2) [5].
Source: X2Rail
Kind: Technical operational actor

<b>Serviceable train</b>
--------------------------

The serviceable train is the physical train unit with its On-board Automation System (OAS).
Source: R2DATO WP5
Kind: Technical operational actor

<b>Train as organization</b>
This 'train as organization' is the serviceable train plus the human actors of RU on-board. The passengers are not part of it.
Source: R2DATO WP5
Kind: Used by: ?

### 8.3 LOGICAL SYSTEMS



<b>Fleet Management System</b>
--------------------------------

The Fleet Management System owned by the railway undertaking provides all central automation functions from gathering and supervising the status of each train down to controlling commands for each train.
Source: R2DATA WP5, X2Rail: see 'Train management'.
Kind: Technical operational actor

<b>OAS - On-board Automation System</b>
On-board Automation System provides all on-board automation functions. It ranges from performing the operational tasks of a train, including control and supervision of the train speed and position, down to control of passenger doors and passenger information system. OAS gathers all on-board logical components including ADM, APM, ETCS-OB, OMTS, PER, REP, LOC, SCV, PIS and TCMS.
Source: R2DATO WP5
Kind: Technical operational actor

## 8.4 HMI COMPONENTS

Those components may be used by the operational analysis as 'in-between' components while specifying interactions between humans and the train.

- 1 Only on-board HMI components are gathered as common. Coordination / Trackside processes are not scope of R2DATO, hence this level of detail, while allowed in the use-cases, is not considered common to all.
- 2 Components for drivers and passengers are considered.

<b>On-board Multimedia and Telematic Subsystem</b>
The On-board Multimedia and Telematic Subsystem (OMTS) provides various information to Passenger through visual, voice or other media.
Source: X2Rail
Kind: HMI

<b>Passenger Alarm System</b>
-------------------------------

A Passenger Alarm System is one of several identical devices situated in the passenger compartment of a train.

- 1 An emergency lever at doors or emergency button allows passengers to report an emergency to the railway undertaking.
- 2 An information button in any colour but red push button allows passenger to request some information – without less criticality than above.
- 3 A combined Microphone + Loudspeakers allows for communication between passenger and railway undertaking staff.

If the emergency lever is pulled/ the emergency button is pushed while the train is in a station, or leaves the platform, the train is immobilized by an emergency brake intervention.

If the emergency lever is pulled/ the emergency button is pushed while the train has left the station, it can continue its course. As the driver (remote) answers the call, the train tries to relieve him/her from her cognitive tension as far as possible, either by coasting or actively reducing its target speed.

If the information button is pressed, the train is not stopped. As the driver (remote) answers the call, the train tries to relieve him/her from her cognitive tension as far as possible, either by coasting or actively reducing its target speed.

Not all systems may implement all 3 functions. The door emergency lever equips normally only systems close to a door.

Below are photos of a device originating ~1920 (Wikipedia) and modern devices by Pickersgill-Kaye or SADEL:



Source: R2DATO WP5

Kind: HMI

<b>ATO-Engage Button</b>
A button provided on the driver panel to engage ATO – see S-125 for details.
Source: X2Rail, S-125
Kind: HMI

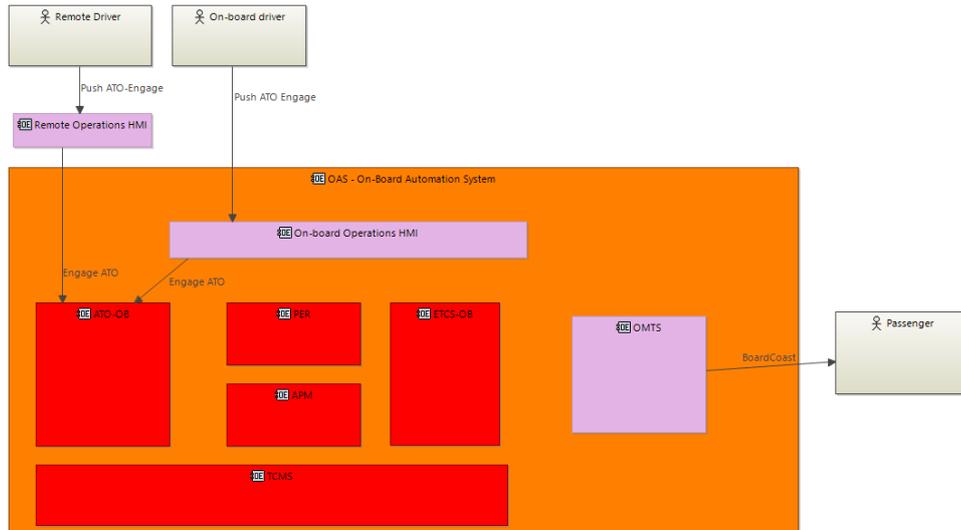
<b>RSC-ClaimGrant Button</b>
A button provided on the driver panel to negotiate the control of the train – see definition by WP5.4.
Source: R2DATO WP5
Kind: HMI

<b>Traction and brake Levers</b>
Lever(s) used by the on-board driver to drive the train, typically traction lever, EDB lever, pneumatic brake lever. From an R2DATOA ATO-OB functional point of view, all levers considered together provide only three different positions: <ul style="list-style-type: none"> <li>• Traction: when it is requesting the rolling stock to traction.</li> <li>• Neutral: when it is requesting the rolling stock neither to traction nor braking.</li> <li>• Braking: when it is requesting the rolling stock to brake.</li> </ul>
Source: R2DATO Project terminology
Kind: HMI

## 8.5 LOGICAL COMPONENTS

This chapter gathers the components of the Onboard Automation System:

- as imported by WP5 from ERTMS, UNISIG or X2Rail-4.
- used to specify degraded operation use-cases.
- discouraged otherwise – which does not diminish their importance in the later design.



<b>ETCS-OB</b>
ETCS-OB is the ATP on-board the train.  The name is taken from ETCS/ERTMS specifications. It corresponds to X2Rail v0.1 's 'Train Protection'.
Like X2Rail's train protection, it contains train integrity monitoring, but also some specific modules for application projects (STMs or national protection systems).
Source: UNISIG
Kind: Logical components

<b>TCMS - Train Control and Monitoring System</b>
The Train Control and Monitoring System (TCMS) controls the various systems installed in the Physical Train Unit with which an interaction is necessary in order to perform automatic railway operation (brakes, traction...).
TCMS functions are extracted from EN 15380-4 (5.3.2, code H).
Source: UNISIG, X2Rail
Kind: Logical components

<b>PER - Perception</b>
<p>The Perception (PER) component is in the train and senses the Physical Railway Environment in place of a driver.</p> <p>Application: GoA3, GoA4.</p> <p>Rationale: module introduced by X2Rail, dedicated to perception with a possible synergy with other sectors like automotive one. Interoperable/interchangeable module active in GoA3/4. Upgradability is possible with technology evolution. C21 is not interoperable by nature.</p>
Source: X2Rail
Kind: Logical components

<b>APM - Automatic Processing Module</b>
<p>The Automatic Processing Module (APM) component is in the train and should substitute driver and train attendant responsibilities for reacting in case of incident. It manages mission execution, safe reflexive reactions, evaluated reactions and safety procedures in cooperation with ISM.</p> <p>Application: GoA2, GoA3, GoA4.</p> <p>Rationale: module introduced by X2Rail, emulating the driver in GoA3/4. Interoperable/interchangeable module active in all GoA levels (GoA2 will be selected by default if there is no Mission Profile).</p>
Source: UNISIG, X2Rail,
Kind: Logical components

## 9 TRAIN OR TRACK VICINITY

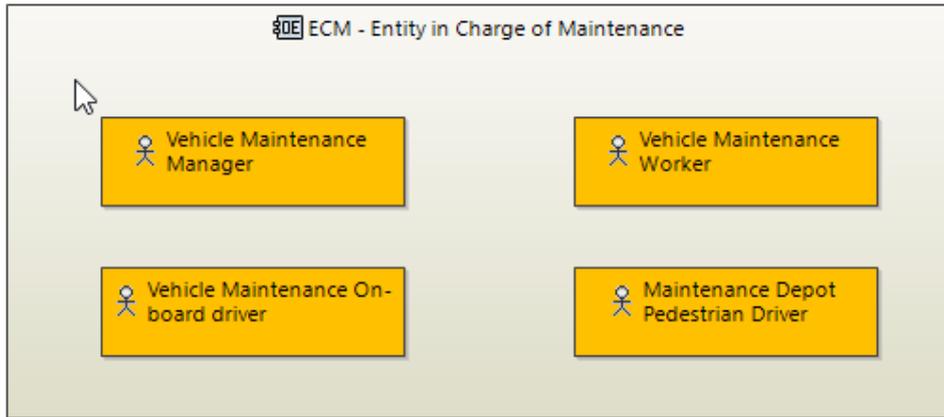
This chapter gathers obstacles for the train. Staff may be documented along with the infrastructure manager and railway undertaking.

<b>Pedestrian on track (shortened pedestrian)</b>
<p>A pedestrian on track, shortened pedestrian if the context is clear, lies the vicinity of the track vicinity. He stands or is walking on railway ground, in the area constituted by the track and its surroundings. The main characteristic of this pedestrian is that he/she may lie in the loading gauge of a track, or enter it without motion other than walk, jog, run, jump. He / she does not need to climb a fence or jump from artefact hanging over the railway ground (adjacent building, bridge).</p> <p>This pedestrian may rely on mature life-saving skills in the vicinity of trains (track maintenance staff, shunting staff, other infrastructure manager staff, train maintenance staff), middle life-saving skills in the vicinity of trains (medical assistance teams, police officers) or not (trespasser).</p> <p>Pedestrians may be found at pedestrian hot-spots (platform, level-crossing) or in the open track.</p>
Source: R2DATO
Kind: Human operational actor

<b>Fire</b>
<p>A Fire is defined by <a href="https://en.wikipedia.org/wiki/Fire">https://en.wikipedia.org/wiki/Fire</a> as “the rapid oxidation of a material (the fuel) in the exothermic chemical process of combustion, releasing heat, light, and various reaction products.”</p> <p>In R2DATO, a fire is something burning on or along the track, in the train, on a platform. According to its size, it endangers humans, vehicles, or infrastructure. It shall be extinguished.</p> <p>Some incidents shall permit to coordinate all actions to this purpose.</p>
Source: R2DATO WP5
Kind: Technical operational actor

**10 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.



Vehicle Maintenance Manager
Coordinator of maintenance works on a train.
Source: X2Rail
Kind: Human operational actor

Vehicle Maintenance On-Board Driver
A driver on-board the train, whose accreditation may be limited to a maintenance yard.  The vehicle maintenance on-board drive relies on the on-board operations HMI, potentially with some limitations (speed limit). He/she may also enhance this HMI with some computer he/she brought in the cab.
Source: R2DATO WP5
Kind: Human operational actor

Vehicle Maintenance Worker
<p>Some professional in a train maintenance yard. The maintenance worker interacts with the train while maintaining it or while being approached by the train in motion.</p> <p>The maintenance worker does not drive the train, either on-board or as a pedestrian: if he/she does this, he/she shall be considered in the role maintenance on-board driver or maintenance pedestrian driver.</p>
Source: R2DATO WP5
Kind: Human operational actor

Maintenance Depot Pedestrian Driver
<p>Some ECM employee allowed to move the train while located in its vicinity, for instance with a simple interface of a tablet or smartphone.</p> <p>This pedestrian driver should be located close to the train front end, to avoid accidents. He/she may negotiate the control of the train with another pedestrian driver located at the other extremity of the train (change direction).</p>
Source: WP5.4
Kind: Human operational actor