IP FA2 Cluster: Enabling Digital Technologies

Track Train Communication Sessions Management Principles

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ABBREVIATIONS AND ACRONYMS

ASTP	Advanced Safe Train Positioning
ATO	Automatic Train Operation
ATO-OB	ATO on board
ATO-TS	ATO trackside
CR	Change Request
DAS	Driver Advisory System
DR	Digital Register
ERJU	Europe's Rail Joint Undertaking
ETCS	European Train Control System
EUG	ERTMS Users Group
FA	Flagship Area
FP	Flagship Project
GNSS	Global Navigation Satellite System
GoA	Grade of Automation
HS	Handshake
IM	Infrastructure Manager
IP	Innovation Pillar
MA	Movement Authority
OB	On-Board
OCORA	Open CCS On-board Reference Architecture
REP	Repository
RU	Railway Undertaking
SIL	Safety Integrity Level
SoM	Start of Mission
TMS	Traffic Management System
TSI	Technical Specifications for Interoperability
TTC	Train Track Communication
WP	Work Package

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1 DEFINITIONS

Term	Definition
Area of Control	A Transactor Area of Control is the area corresponding to the railway lines for which the Transactor is responsible for providing Segment Profiles and/or Journey Profiles.
Cold Movement Detector	As per clause 3.15.8 from Subset-026, A Cold Movement Detector surveys the fixed distance for small movements in No Power mode. It states if the last known position can be used safely after power on.
Daily Reference Train-ID	Unique identification of a service defined in the theoretical timetable as specified in TAF/TAP regulation.
Digital Map	"Digital Map comprises several layers of data representing the railway network as necessary for different consuming applications. Common to all layers is the fact, that they all are related to a piece of physical track."
Digital Register (DR)	The Digital Register is a data management system responsible for handling static infrastructure data used to configure central, trackside and on-board systems of the railway control command and signalling systems.
Inactive communication	The Track Train Communication is in an inactive state when there is no Communication Session established.
Map Area	A Map Area is defined as the area surrounding the position of the train, providing the a list of Segment Profiles around the train position. A Map Area includes information containing Segment Profile ID and Segment Profile Version. A train position can be: • The 1D position (last known Segment Profile ID and distance from the beginning of this Segment Profile) • And/or the 3D position (x,y,z coordinates) Map Area includes information containing Segment Profile ID and Segment Profile Version. A DR provided Map Area legitimates the consumer to use it as correct infrastructure data.
NID_Operational	Identification of a service defined in the theoretical timetable. This ID is given to the ETCS-OB (currently by the driver). In some way, it corresponds to the Daily Reference Train-ID.
Parameter Data	Parameter Data define the system configuration data required for national and supplier-specific operative environments. A notable example of such data is ETCS national values.

Reliable Data	Reliable Data refers to a typical characteristic of data which satisfies the qualities of being trustworthy/low probability of incorrect information/low fault rate of the information, current (not obsolete), complete, and accurate.
Repository	Repository is an on-board logical block supporting Track/Train communication for the on-board applications.
Safety Critical Data	Safety-critical data refers to a form of reliable data used for safety critical applications.
Segment Profile	A Segment Profile is a one-dimensional object that describes a set of static infrastructure data required for on-board applications like localisation, perception, and ATO.
Time critical Data	Time critical data refers to information that must be received, processed, and acted upon within a strict time frame to ensure the desired outcome or prevent negative consequences. Delays in processing or transmitting this data can lead to safety hazards. It is in-fact the safety critical data used for time critical applications like revoking authorised train movement, transmission of Signal states, transmission of point states, etc.
Timing Point	As defined in [2], A location and stopping accuracy defined in the Segment Profile for which a type (Stopping or Passing Point) and specific time is identified in the Journey Profile. This time may be an arrival time, a departure time, or in the case of a train not scheduled to stop at that location, the passing time.
Transactor	A Transactor is a trackside “service” hosting the access to one or several trackside functions delivering data to be transmitted to on-board consumers. There are three types of Transactors: - Digital Register Transactors; - Traffic Management Transactors; - Train Management Transactors.

2 INTRODUCTION

2.1.1.1 It was identified in R2DATO FA2 Innovation Pillar WP27 that there exist several initiatives / projects like RCA, OCORA, TSI 2023, X2R4, ERJU, IP FA 2 WP 27 which define the different application domains of Digital Register. Owing to such diversity on the Digital Register topics, this working group was defined within the framework of “Enabling Digital Technologies Cluster” in Innovation Pillar FA2 R2DATO to analyse these different projects and standardise the needs of Digital Register for the airgap. The results from this working group are envisaged to be shared with relevant domains in ERJU System Pillar and WP3 IP FA 2 to enable usage of already defined specifications, design criteria, rationale, architecture decisions, etc.

2.1.1.2 The objective of this document is to describe the principles/rules applicable for the track train communication related to control command and signalling systems and subsystems. It concerns all related applications on-board and trackside except for:

- the ETCS on-board and trackside supported by the Subset-026, containing safe data and time critical data;
- the direct interface with the Rolling Stock supporting the train specific diagnosis and remote control.

2.1.1.3 These Track Train Communication principles are also applicable to use case like Driver Advisory Systems (e.g. implemented on the tablet-pc of the driver).”

2.1.1.4 This document relates to Track Train Communication principles limited to the Application layer of OSI model (cfr. Level 7 in Figure 1).

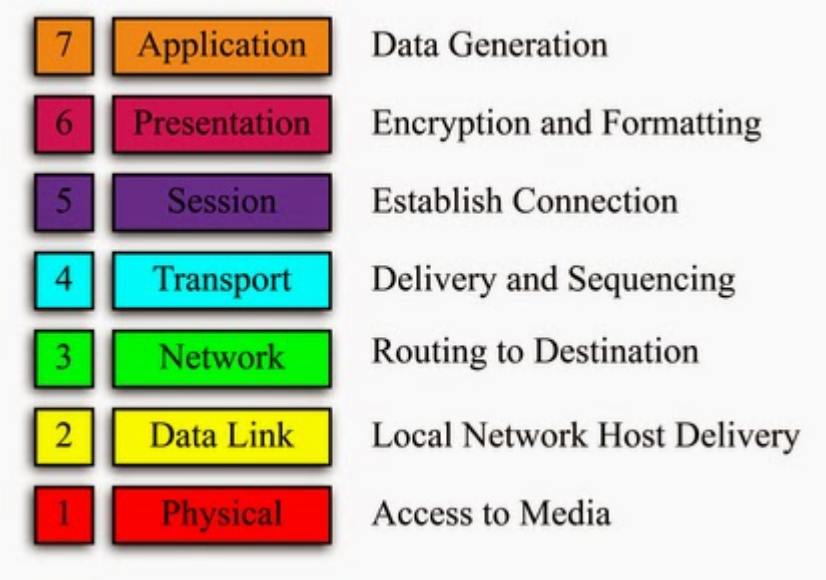

Figure 1 – OSI model for communication layers

2.1.1.5 The system functions involved in realising the track train communication must not modify the data. The integrity of data shall be secured by sufficient measures.

2.1.1.6 The purpose of these Track Train Communication principles is to facilitate also future migrations across the subsequent versions of the control command and signalling system guaranteeing the backward and forward compatibility in the next decades.

2.1.1.7 A most recent train shall be able to be operated in a trackside area fitted with an older system version. And a trackside area fitted with a most recent system version shall be able to operate train fitted with an older system version.

2.1.1.8 Adding new applications on-board and/or trackside shall be possible without jeopardising the standard Track Train Communication principles.

2.1.1.9 The track train interface specification shall be easily upgradable supporting additional data required for new applications.

3 CONTEXT

3.1 Scope of the document

3.1.1.1 The scope of the document "The scope of the document is Track Train interfaces including generic principles like versioning, application layer structure, architecture, migration, consider assumptions/requirements regarding non-functional aspects like performance, data volume, safety, security.

3.2 Not in Scope of WG

3.2.1.1 The Track Track interfaces for configuration of trackside systems and On-board interfaces (i.e. REP to ASTP/ ATO-OB…) are not in scope.

3.3 Constraints

3.3.1.1 Since some data will be used within SIL4 functions the Track Train Communication principles need to be reliable. The processing chain needs to fulfil SIL4 requirements as well for the relevant data.
Note: For “reliable data” see definitions
Source: IP FA 2 WP21/22

3.3.1.2 The packets related to the hand shaking process should not be changed for backward and forward compatibility, communication session management. The conditions for handshake in comparison to today’s SUBSET-125 can change.
Source: X2R4 ATO up to GoA4

3.3.1.3 As foreseen in TSI 2023, a train does not need to be configured according to the trackside: no parameter data, no map data. The RU shall be able to allocate a train or a train consist to a service without being obliged to check, regarding track train communication, if it is fit for purpose (correctly configured to be operated on the corresponding line).
Note: pre-storing is optionally still possible (e.g. for migration, limited communication), but not require.
Source: X2R4 ATO up to GoA4

3.3.1.4 The IM must be able to change any configuration data (e.g. signalling data) without being obliged to inform all the RUs possibly operating some trains on the corresponding line.
Source: X2R4 ATO up to GoA4

3.3.1.5 The data sent via the communication interfaces in compliance to principles defined in this document are not considered to be time critical in the sense of missing safety targets. Consequently, no data is transmitted that is characterized as safety- *and* time critical.
Note: This approach allows the usage of public radio, if required for coverage.
Note2: Hereby the channel differentiates from existing track train communication channel, used for providing (almost) real-time information such as Movement Authorities or Movement Authorities revocations.
Source: WG Agreement

3.3.1.6 The ETCS communication is not part of the track train communication channel discussed here. The ETCS airgap (SUBSET-026) remains unchanged when introducing this approach.
Source: TSI 2023 and X2R4 ATO up to GoA4

3.4 Assumptions

3.4.1.1 The Traffic Management Systems, through its optimised planning process, avoids the change of topology under the rolling wheel. This assumption avoids the potential time critical situation due to Map Area updates.

3.4.1.2 Transactors can have borders at different locations. Ergo, handovers can take place at different locations.

3.4.1.3 The Track Train Communication Principles are compatible to the System Pillar CCS/TMS Data Model.

3.4.1.4 Map Area Requests are performed based on the train position from ASTP. The position can be 1D or 3D.

3.4.1.5 There can be locations where ASTP cannot determine initial position. When this initial position is not available, Map cannot be requested from trackside. During such rare cases, running in ETCS Mode Staff Responsible (with or without Remote Driving) is the solution.

3.4.1.6 A DR provided Map Area legitimates the consumer to use it as correct infrastructure data. Non-required Segment Profiles are deactivated to ensure obsolescence management.

3.4.1.7 Offline preloading of map data shall be possible, as already supported in TSI 2023. However, it is expected that use cases involving higher data volumes (e.g. GigaByte/km) will be utilised, as (for example and illustration only in the context of GoA4 - Perception requiring 3D scene data). To support the efficient loading and updating of high data volumes, a demand/route-based request for data is also considered within the presented principles. In such cases, there shall be an online process to ensure obsolescence management of the map data.

3.4.1.8 For migration purposes, a stepwise implementation of the Digital Register with respect to the extension of the covered area as well as to the available content for the different applications is anticipated. This is also because reliable data is not entirely available for the railway network. Consequently, the applications must work according to these conditions and expect degraded situations. For example Full ASTP without a Map has to function on odometry and Balise principles.

3.4.1.9 The presence of outdated map data in Repository on-board can be prevented via the trackside map data update process (Chapter 5.1.3 in the deliverable D27.1 [1])

4 BASIC PRINCIPLE

4.1 Segment Profile concept

4.1.1.1 The Segment Profile concept as defined in TSI 2023 SUBSET-125 and SUBSET-126 has been extended to cater the needs of further onboard consumers like ASTP and ATO up to GoA4.

4.1.1.2 The CCS/TMS Data Model from Transversal CCS Domain in System Pillar is used as the standardised Data Model for the Track Train Communication principles document.

4.1.1.3 The CCS/TMS Data Model comprises of the Track Edge and Track Edge Links building up the base topology layer of the Data Model.

4.1.1.4 A Track Edge is a linear object that defines an uninterrupted stretch of a railway track without divergence or convergence. A Track Edge is defined along the centre line of the 2D or 3D track alignment and has a finite length. A Track Edge is associated with Track Edge Links to determine navigabilities between Track Edges.

4.1.1.5 A Track Edge Link defines a relation between two Track Edges along which a train can run. Track Edge Links determine which travel options are permitted at points and which are excluded. They are necessary to eliminate the physically impossible train movements (e.g. a movement from the left to the right branch of a point).

4.1.1.6 A Track Edge Section is a simple container for three attributes defining part of a Track Edge. It is used by other objects as supporting data-object (e.g. Track Edge Gauges). Track Edge Sections have reference points defined to indicate their start and end locations. The reference points are defined using distance skips from start and end of Track Edges. The starting/ending point is to calculate as a distance increment/decrement from start/end of Track Edge respectively. Track Edge Section is always limited to one Track Edge i.e., they cannot be defined over multiple Track Edges.

4.1.1.7 The Track Edge Section is enriched with a “direction” attribute building a Directed Track Edge Section.

4.1.1.8 The Segment Profiles are simply abstractions of the base topology. Since Segment Profiles can be different according to direction of travel, the abstractions are supplemented using Directed Track Edge Sections on the Track Edge level to allow separation as well as layering in the CCS/TMS Data Model.

4.1.1.9 Each Segment Profile has a unique ID and version number.
Note: Versioning is done on the Segment Profile Level to keep things compliant with the versioning mechanisms done today for SPs as part of TSI2023

4.1.1.10 On the CCS/TMS Data Model level, Segment Profile is a collection of all the objects required according to needs of consumers.

4.1.1.11 On the interface level, the Segment Profile can look different according to the interface needs (bandwidth limitation, available on-board storage, etc.).

4.1.1.12 This view of the Segment Profile on the interface level can look as in the figure below

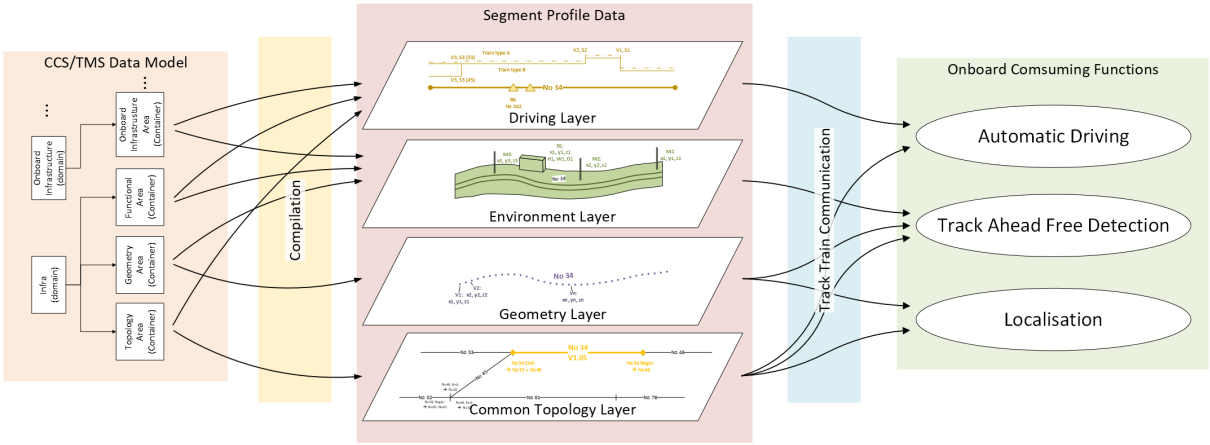

Figure 2 – Segment Profile concept (with layers)

4.1.1.13 For example, in the previous figure, the following layers can be seen:

- the Geometry Profile defining the vertices required for the Perception application and the Localisation application (ASTP);
- the Environment Profile defining the fixed objects present in the environment of the track required for the Perception application;
- the Driving Profile defining the items required for the Automatic Driving Module application (as specified in the SUBSET-126 from the TSI 2023);

4.1.1.14 The interface view / layers can be derived using compilers based on the CCS/TMS Data Model.

4.1.1.15 The layered implementation is scalable to other on-board applications (even not known today) without jeopardising the Track Train Communication principles and preserving the forward/backward compatibility.

4.1.1.16 The Segment Profile is delivered by the Digital Register sub-system via a DR Transactor which is a server managing the track train communication.

4.1.1.17 In addition, the CCS/TMS Data Model is enriched with different containers like Geometry Area, Track Properties Area, Functional Area, etc. to represent all the other properties and objects on the base topology.
Note: Container refers to a CCS/TMS Data Model object that contains the properties belonging to a particular topic.

4.1.1.18 Owing to requirements from different data consumers, the CCS/TMS Data Model is further divided into Domains addressing the specific needs.
Note: Domain refers to different application domains of the Data Models such as On-board, Train Protection, Infrastructure, Operational Plan, etc.

4.1.1.19 For more detailed information regarding the CCS/TMS Data Model, refer to the Data Model publication here.

4.2 Repository concept

4.2.1.1 The on-board management of the track train communication is supported by a dedicated application (so-called Repository).

4.2.1.2 The consuming on-board applications (like Perception, Automatic Driving or ASTP) request the Repository which Layers and to which geographic extent (specified by Journey Profile or a Map Area) they require to be informed.

4.2.1.3 When requesting a Segment Profile or a Map Area to the DR Transactor, the Repository mentions which Layers shall be transmitted.

4.2.1.4 The Segment Profiles may be permanently stored on-board in the Repository in advance as preparation for further usage.

4.3 Map Area concept

4.3.1.1 A Map Area determines the required set of Segment Profiles surrounding a given train position provided by ASTP. For rational, see assumption 3.4.1.8. For position see Definitions.

4.3.1.2 The Map Area contains the list of IDs of Segment Profiles located around the train. And, associated to each ID of Segment Profile, it gives the corresponding version number.

4.3.1.3 A DR provided Map Area legitimates the consumer to use it as correct infrastructure data.

4.3.1.4 The Map Area which has already been used by train for a journey or deemed as non-required are deactivated for usage to ensure obsolescence management.

4.3.1.5 The Map Area is delivered by the DR Transactor to Repository on a “Map Area Request” which includes the train position (1D and/or 3D).”

4.3.1.6 During an update of the Segment Profiles, the Map Area is provided as an update with all the required Segment Profiles to all the connected trains which are affected by this update.
Note 1: The trains which are affected by the update of some Segment Profiles are the ones operating inside a Map Area previously given by the DR Transactor and containing at least one of the updated Segment Profiles
Note 2: The size of the Map Area to be transmitted as part of the update is subjective to the interoperable storage needs on-board.

4.3.1.7 When a required Segment Profile is not yet stored on-board or if it is outdated, the Repository sends a Segment Profile request to the DR Transactor which shall send the latest version of the corresponding Segment Profile.

4.3.1.8 The Map Area and the related Segment Profiles are provided by the Digital Register sub-system via a DR Transactor which is a server managing the track train communication.

4.3.1.9 Each Map Area Request shall be associated with a parameter to determine the radius to be considered around the train based on which the Map Area is provided

to the train.

4.4 Journey Profile concept

4.4.1.1 The Journey Profile basically contains two sets of information:
- the list of the Segment Profiles which are required for the train to operate;
- the list of Timing Points with the expected passing time, arrival time and departure time.

4.4.1.2 For each Segment Profile in the list, the Journey Profile contains the ID and version number of each Segment profile.

4.4.1.3 Optionally, The Journey Profile may contain several alternative Journey Profiles which will be considered by the Repository when detecting that there is a change of route without having received any Journey Profile update.

4.4.1.4 The Journey Profiles are delivered by the Traffic Management System via a Traffic Mgt Transactor which is a server managing the track train communication.

4.5 Mission Profile concept

4.5.1.1 Intentionally left empty due to unavailability of mature concepts.

4.6 Train Data Concept

4.6.1.1 Intentionally left empty due to unavailability of mature concepts.

4.7 Transactor concept

4.7.1.1 A Transactor belongs to an IM, or a RU or to another company, depending on the data to be hosted and the roles and responsibilities in the specific application.

4.7.1.2 One example of implementation is to host the Mission Profiles and Train Data inside a Transactor belonging to the RU while the Journey Profiles and Segment Profiles are hosted by a Transactor belonging to the IM.

4.7.1.3 Another implementation is to host all those data in the same Transactor belonging to an IM assuming the relevant data are provided by the RU to IM.

4.7.1.4 Below in this document, the Transactors providing data to the on-board system are named as follows:
- "**Train Mgt Transactor**" the one providing the Mission Profile and the Train Data;
- "**DR Transactor**" the one providing the Segment Profiles and Map Area;
- "**Traffic Mgt Transactor**" the one providing the Journey Profiles and possibly the Segment Profiles when connected with the train fitted for Up to GoA2 (TSI 2023);

4.7.1.5 A priori, a Train Mgt Transactor belongs to and is managed by an RU while Traffic Mgt Transactor, DR Transactor belong to and are managed by the IM.

4.7.1.6 Nevertheless, in some application or country, the Train Mgt Transactor, the Traffic

Mgt Transactor, the DR Transactor may belong to the same entity (IM or RU).

4.7.1.7 In this case the three Transactors may be hosted by the same physical server having, for each connected train, 3 communication sessions opened.

4.7.1.8 Depending on the level of safety of the particular data a safety layer needs to be added to the data and maybe also for the communication channel following the results of a safety analysis.

4.7.1.9 The logical architecture based on Transactors is modular and adaptable depending on the application.

4.8 Transactor Contact Information

4.8.1 Introduction

4.8.1.1 The “Transactor Contact Information” is used to identify the trackside service (Transactor) which will be able to answer to a request from the on-board Repository (e.g. Map Area, Segment Profiles, Journey Profile, Mission Profile or Train Data).

4.8.1.2 Two configuration parameters are stored in the Repository.

4.8.1.3 The first one is used to have access to the appropriate DR Transactor.

4.8.1.4 The second one is used to have access to the appropriate Train Mgt Transactor or Traffic Mgt Transactor.

4.8.2 Preconfigured DR Transactor Contact Information

4.8.2.1 The “Preconfigured DR Transactor Contact Information” is used to access a DR Transactor. It is the responsibility of this DR Transactor to always be able to deliver:

- a Map Area and the Segment Profiles;
- or the Contact Information of the DR Transactor able to deliver the appropriate Map Area according to the current train position.

4.8.2.2 When waking-up, the Repository will send an Handshake Request (HSReq) to the preconfigured DR Transactor giving its localisation (1D position and/or 3D position). ASTP provides this localisation information to Repository during wake-up.

4.8.2.3 If the train is inside the Area of Control (AoC) of this preconfigured DR Transactor, then this one will accept the Handshaking (Hsack) and it will answer to any Map Area or Segment Profile request sent by the Repository.

4.8.2.4 If the train is outside this Area of Control, then the DR Transactor will reject the Handshaking (HSRej) giving the Contact Information of the DR Transactor where the train is located.

4.8.2.5 To support this, the preconfigured DR Transactor shall be able to determine the appropriate Contact Information of the DR Transactor where the train is located. This implies the definition and storage of the different Areas of Control in Europe giving the corresponding Contact Information.

4.8.2.6 Segments Profiles ending at a border between two DR Transactors contain the

Contact Information of the adjacent DR Transactor. This permits to open a communication session with the "accepting" DR Transactor when approaching the border.

4.8.3 Preconfigured Train/Traffic Transactor Contact Information

4.8.3.1 The "Preconfigured Train/Traffic Transactor Contact Information" is used to access a Transactor which could be a Train Mgt Transactor or a Traffic Mgt Transactor. It is the responsibility of this Transactor to always be able to deliver:
- or a Mission Profile;
- or a Journey Profile;
- or the Contact Information of the Traffic Mgt Transactor able to deliver the appropriate Journey Profile according to the current train position.

4.8.3.2 If this "preconfigured" Transactor is the appropriate one to deliver a Mission Profile, it will accept the communication session (handshake acknowledgment). When it is not the case, the Transactor will send the appropriate Contact Information in the handshake rejection packet. This Contact Information could refer to a Train Mgt Transactor or to a Traffic Mgt Transactor.

4.8.3.3 If any, the Mission Profile Data contain the Transactor Contact Information of the Traffic Mgt Transactor which shall deliver the Journey Profile.

4.8.3.4 In addition, Segment Profiles ending at a border between two Traffic Mgt Transactors contain the Contact Information of the adjacent Traffic Mgt Transactor. This permits to open a communication session with the "accepting" Traffic Mgt Transactor when approaching the border.

4.8.4 Summary

4.8.4.1 To summarize, the Transactors Contact Information are given by:
- For the DR Transactor:
  - Preconfigured DR Transactor Contact Information;
  - Or the Handshake Rejection packet when connecting the Preconfigured DR Transactor;
  - or the Segment Profile at the border between 2 DR Transactors.
- For the Train Mgt Transactor:
  - the Preconfigured Train/Traffic Mgt Transactor Contact Information;
  - Or the Handshake Rejection packet when connecting the Preconfigured Train/Traffic Mgt Transactor.
- For the Traffic Mgt Transactor:
  - the Preconfigured Train/Traffic Mgt Transactor Contact Information;
  - or a task in the Mission Profile;
  - or the Segment Profile at the border between 2 Traffic Mgt Transactors.

4.9 Handshaking process and version management

4.9.1.1 The packets involved in the handshaking process are universal in the sense that they need not to be changed when the system version will be updated implementing new functions (e.g. when migrating from GoA2 to GoA3/4).

4.9.1.2 This concerns the following packets: DR_HSReq, HSReq, HSAck and HSRej.

4.9.1.3 During the handshaking process, the Repository and the corresponding Transactor exchange the supported system versions and select the highest version supported by both.

4.9.1.4 This system version agreed by both the Repository and the Transactor determines the content and format of the exchanged packets.

4.9.1.5 The DR_HSReq packet is used to open a Communication Session with a DR Transactor. It includes:
- The NID_OPERATIONAL;
- The NID_ENGINE;
- The list of System Versions supported by the on-board system;
- The 3D train location;
- The 1D train location (if any).

4.9.1.6 The HSReq is used to open a Communication Session with a Train Mgt Transactor or with a Traffic Mgt Transactor. It complies with the TSI 2023 specification (SUBSET-126 v 1.0.0) including:
- The NID_OPERATIONAL;
- The NID_ENGINE;
- The list of System Versions supported by the on-board system.

4.9.1.7 Note : In the case there is no NID_OPERATIONAL on-board yet. i.e. A train fitted for GoA4 wants to open a communication with the Train Mgt Transactor with a HSReq. It doesn't have any NID_OPERATIONAL yet (in fact, it is the Train Mgt Transactor that will give the train a NID_OPERATIONAL once the communication is established). In that case, it is foreseen that a special "unknown" value is used for that variable in the handshake request.

4.10 Fitted trackside area

4.10.1.1 An area is considered as fitted where there are Transactors able to deliver at least one of Map Area or Journey Profiles (with their related Segment Profiles) on request from a train unit.

4.10.1.2 A fitted trackside area is solely under the responsibility of an Infrastructure Manager. Hence, it consists of IM relevant transactors like DR and Traffic Management. Train Mgt Transactor is not considered when defining a fitted trackside area since it is under the responsibility of RU.

4.10.1.3 At the contrary, an area is considered as non-fitted where no Transactor can deliver any Map Area, Journey Profiles or Segment Profiles.

4.10.1.4 A non-fitted area is such that no Server is existing supporting the any Transactor service for this area.

4.10.1.5 A fitted trackside area may be fitted for the following types of operation:
- "(TSI 2023 or older) Up to GoA1";
- "(TSI 2023) Up to GoA2";
- "(TSI 20xx) Up to GoA1 with ASTP";
- "(TSI 20xx) Up to GoA2 with ASTP";

- "(TSI 20yy) Up to GoA4 with ASTP".
  Note: TSI 20xx / TSI 20yy are referred as future version of TSI's that cover the specifications related to concepts "Up to GoA1 with ASTP", "Up to GoA2 with ASTP", and "Up to GoA4 with ASTP".

4.10.1.6 When fitted for "(TSI 2023 or older) Up to GoA1" the current Track Train communication is not applicable.

4.10.1.7 When fitted for "(TSI 2023) Up to GoA2" operation, the corresponding Area of Control is supported by:
- A Transactor able to deliver Segment Profiles and Journey Profiles compliant with the TSI 2023.

This corresponds to the ATO-TS currently defined in the TSI 2023.

4.10.1.8 When fitted for "(TSI 20xx) Up to GoA1 with ASTP" operation, the corresponding Area of Control is supported by:
- a DR Transactor able to deliver Map Area and Segment Profiles compliant with the TSI 20xx supporting ASTP application on-board.

4.10.1.9 When fitted for "(TSI 20xx) Up to GoA2 with ASTP" operation, the corresponding Area of Control is supported by:
- A Transactor able to deliver Segment Profiles and Journey Profiles compliant with the TSI 2023;
- A Traffic Mgt Transactor able to deliver Journey Profiles compliant with the TSI 20xx;
- a DR Transactor able to deliver Map Area and Segment Profiles compliant with the TSI 20xx supporting ASTP application on-board.

4.10.1.10 When fitted for "Up to GoA4" operation, the corresponding Area of Control is supported by:
- a DR Transactor able to deliver:
  - Map Area and Segment Profiles compliant with the TSI 20yy;
- a Traffic Mgt Transactor able to deliver:
  - Journey Profiles compliant with the TSI 20yy;
  - Journey Profiles and Segment Profiles in compliance with the TSI 2023.

4.11 Train fitment

4.11.1.1 A train is considered as fitted when there are on-board applications able to request at least one of Mission Profile (with its related Train Data) or Map Areas (with their related Segment Profile) or Journey Profiles (with their related Segment Profiles).

4.11.1.2 On the contrary, a train is considered as non-fitted where no on-board application will be able to request any Mission Profile (with its related Train Data) or Map Areas (with their related Segment Profile) or Journey Profiles (with their related Segment Profiles).

4.11.1.3 A train may be fitted for the following types of operation:
- "(TSI 2023 or older) Up to GoA1";
- "(TSI 2023) Up to GoA2";
- "(TSI 20xx) Up to GoA1 with ASTP";
- "(TSI 20xx) Up to GoA2 with ASTP";

- "(TSI 20yy) Up to GoA4 with ASTP".

4.11.1.4 When fitted for "(TSI 2023 or older) Up to GoA1" the current Track Train communication is not applicable.

4.11.1.5 When fitted for "(TSI 2023) Up to GoA2", the train shall be able to request:
- Journey Profiles in compliance with the TSI 2023;
- Segment Profiles in compliance with the TSI 2023.

This corresponds to the ATO-OB currently defined in the TSI 2023.

4.11.1.6 When fitted for ""(TSI 20xx) Up to GoA1 with ASTP": the train shall be able to request:
- Map Area in compliance with the TSI 20xx;
- Segment Profiles in compliance with the TSI 20xx.

4.11.1.7 When fitted for "(TSI 20xx) Up to GoA2 with ASTP", the train shall be able to request:
- Map Area in compliance with TSI20xx;
- Journey Profiles in compliance with the TSI 20xx;
- Segment Profiles in compliance with the TSI 20xx;
- Journey Profiles in compliance with the TSI 2023;
- Segment Profiles in compliance with the TSI 2023.

4.11.1.8 When fitted for "(TSI 20yy) Up to GoA4 with ASTP", the train shall be able to request:
- Map Area in compliance with the TSI 20xx;
- Journey Profiles in compliance with the TSI 20xx;
- Segment Profiles in compliance with the TSI 20xx;
- Journey Profiles in compliance with the TSI 2023;
- Segment Profiles in compliance with the TSI 2023;
- Map Area in compliance with the TSI 20yy;
- Train Data in compliance with the TSI 20yy;
- Mission Profiles in compliance with the TSI 20yy;
- Journey Profiles in compliance with the TSI 20yy;
- Segment Profiles in compliance with the TSI 20yy.

4.12 Track and train compatibilities

4.12.1.1 As mentioned before, the Repository and the corresponding Transactor exchange, during the handshaking process, the supported system versions and select the highest version supported by both.

4.12.1.2 This system version agreed by both the Repository and the Transactor determines the content and format of the exchanged packets.

4.12.1.3 The following table demonstrates the compatibilities related to the track and train fitment and defines the system versions associated with (according to current situation).

Applicable Track/Train communication version		Trackside fitment				
		(TSI 2023 or older) Up to GoA1	(TSI 2023) Up to GoA2	(TSI 20xx) Up to GoA1 *ASTP*	(TSI 20xx) Up to GoA2 *ASTP*	(TSI 20yy) Up to GoA4 *ASTP*
Train fitment	(TSI 2023 or older) Up to GoA1	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	(TSI 2023) Up to GoA2	Not applicable	TSI 2023	Not applicable	TSI 2023	TSI 2023
	(TSI 20xx) Up to GoA1 ASTP	Not applicable	Not applicable	TSI 20xx	TSI 20xx	TSI 20xx
	(TSI 20xx) Up to GoA2 ASTP	Not applicable	TSI 2023	TSI 20xx	TSI 20xx	TSI 20xx
	(TSI 20yy) Up to GoA4 ASTP	Not applicable	TSI 2023	TSI 20xx	TSI 20xx	TSI 20yy

4.12.1.4 Note: For train fitment up to GoA4 ASTP, the Communication Sessions established with a Train Mgt Transactor is independent from the trackside fitment as defined in the chapter 4.10. It is assumed that a Communication Session with a Train Mgt Transactor is always compliant with the system version “TSI 20yy”.

4.12.1.5 The mention of TSI20xx / TSI20yy does not mean that we envisage release of multiple TSI for specification of the respective operational scenarios. They can be part of other planned TSI.

4.12.1.6 The following table determines the types of data transmitted from trackside to trains depending on the system version selected during the handshaking process.

Transmitted data from track to train		Trackside fitment				
		(TSI 2023 or older) Up to GoA1	(TSI 2023) Up to GoA2	(TSI 20xx) Up to GoA1 ASTP	(TSI 20xx) Up to GoA2 ASTP	(TSI 20yy) Up to GoA4 ASTP
Train fitment	(TSI 2023 or older) Up to GoA1	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	(TSI 2023) Up to GoA2	Not applicable	Journey Profiles Segment Profiles	Not applicable	Journey Profiles Segment Profiles	Journey Profiles Segment Profiles
	(TSI 20xx) Up to GoA1 ASTP	Not applicable	Not applicable	Map Area Segment Profiles	Map Area Segment Profiles	Map Area Segment Profiles
	(TSI 20xx) Up to GoA2 ASTP	Not applicable	Journey Profiles Segment Profiles	Map Area Segment Profiles	Map Area Journey Profiles Segment Profiles	Map Area Journey Profiles Segment Profiles
	(TSI 20yy) Up to GoA4 ASTP	Not applicable	Mission Profile Train Data Journey Profiles Segment Profiles	Mission Profile Train Data Map Area Segment Profiles	Mission Profile Train Data Journey Profiles Map Area Segment Profiles	Map Area Mission Profile Train Data Journey Profiles Segment Profiles

4.12.1.7 The following table determines the communication session established with trackside Transactors delivering the needed data:

Communication Sessions established with Transactors		Trackside fitment				
		(TSI 2023 or older) Up to GoA1	(TSI 2023) Up to GoA2	(TSI 20xx) Up to GoA1 ASTP	(TSI 20xx) Up to GoA2 ASTP	(TSI 20yy) Up to GoA4 ASTP
Train fitment	(TSI 2023 or older) Up to GoA1	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	(TSI 2023) Up to GoA2	Not applicable	**(ATO-TS)** Journey Profiles Segment Profiles	Not applicable	**(Traffic Mgt Transactor)** Journey Profiles Segment Profiles	**(Traffic Mgt Transactor)** Journey Profiles Segment Profiles
	(TSI 20xx) Up to GoA1 ASTP	Not applicable	Not applicable	**(DR Transactor)** Map Area Segment Profiles	**(DR Transactor)** Map Area Segment Profiles	**(DR Transactor)** Map Area Segment Profiles
	(TSI 20xx) Up to GoA2 ASTP	Not applicable	**(ATO-TS)** Journey Profiles Segment Profiles	**(DR Transactor)** Map Area Segment Profiles	**(Traffic Mgt Transactor)** Journey Profiles **(DR Transactor)** Map Area Segment Profiles	**(Traffic Mgt Transactor)** Journey Profiles **(DR Transactor)** Map Area Segment Profiles
	(TSI 20yy) Up to GoA4 ASTP	Not applicable	**(Train Mgt Transactor)** Mission Profile Train Data **(ATO-TS)** Journey Profiles Segment Profiles	**(Train Mgt Transactor)** Mission Profile Train Data **(DR Transactor)** Map Area Segment Profiles	**(Train Mgt Transactor)** Mission Profile Train Data **(Traffic Mgt Transactor)** Journey Profiles **(DR Transactor)** Segment Profiles	**(Train Mgt Transactor)** Mission Profile Train Data **(Traffic Mgt Transactor)** Journey Profiles **(DR Transactor)** Map Area Segment Profiles

4.12.1.8 The colour code in the previous table reminds the system version used for the Communication Sessions with the different Transactors:

- Green: TSI 2023;
- Orange: TSI 20xx;
- Red: TSI 20yy.

4.12.1.9 For a Train fitted for Up to GoA4, the use of Mission Profiles and Train Data is optional on area which are not yet fitted for Up to GoA4.

4.12.1.10 Note: When the trackside is fitted for “(TSI 20xx) Up to GoA2 ASTP” or for “(TSI 20yy) Up to GoA4 ASTP”, the Traffic Mgt Transactor is also compatible to deliver SPs for a TSI2023 train. This means that the Traffic Mgt Transactor will deliver Journey Profiles and Segment Profiles as well.

4.13 Operational contexts related to the track train communication

4.13.1 Introduction

4.13.1.1 The following table determines the different operational contexts which depends on the available Communication Sessions with trackside Transactors:

Operational contexts		Trackside fitment				
		(TSI 2023 or older) Up to GoA1	(TSI 2023) Up to GoA2	(TSI 20xx) Up to GoA1 ASTP	(TSI 20xx) Up to GoA2 ASTP	(TSI 20yy) Up to GoA4 ASTP
Train fitment	(TSI 2023 or older) Up to GoA1	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	(TSI 2023) Up to GoA2	Not applicable	(ATO Jo Segm Ops 2	Not applicable	(Traffi actor) Jou Segm Ops 2	(Traffi actor) Jou Segm Ops 2
	(TSI 20xx) Up to GoA1 ASTP	Not applicable	Not applicable	(DR Tr M Segm Ops 1	(DR T Ma Segm Ops 1	(DR T Ma Segm Ops 1
	(TSI 20xx) Up to GoA2 ASTP	Not applicable	(A Jou Segment Profiles Ops 2	(D Ma Segment Profiles Ops 1	(Traffic Mgt Transactor) Jou (DR Map Area Segment Profiles Ops 3	(Traffic Mgt Transactor) Jou (DR Map Area Segment Profiles Ops 3
	(TSI 20yy) Up to GoA4 ASTP	Not applicable	(Train Mgt Transactor) Mission Profile Tr (A Journey Profiles Segment Profiles Ops 2	(Train Mgt Transactor) Missi Tr (DR Map Area Segment Profiles Ops 1	(Train Mgt Transactor) Mission Profile Train (Tr or) Journey Profiles (DR Transactor) Segment Profiles Ops 3	(Train Mgt Transactor) Mission Profile Train Data (Tra or) Jou (DR Transactor) Map Area Segment Profiles Ops 4

4.13.1.2 From this table, the following operational contexts can be deduced which will be considered for the subsequent Use Cases:

- Ops 1;
- Ops 2;
- Ops 3;
- Ops 4.

4.13.2 Ops 1

4.13.2.1 In the first operational context, the train has only one connection established. This a connection with a DR Transactor able to deliver Map Area and Segment Profiles (see Figure 3).

4.13.2.2 No Communication Session may be established with any Traffic Mgt Transactor.

- Possibly, there will be a Communication Session established with a Train Mgt Transactor in case the train is fit "Up to GoA4" being operated in an area fit for "(TSI 20xx) Up to GoA1 with ASTP".

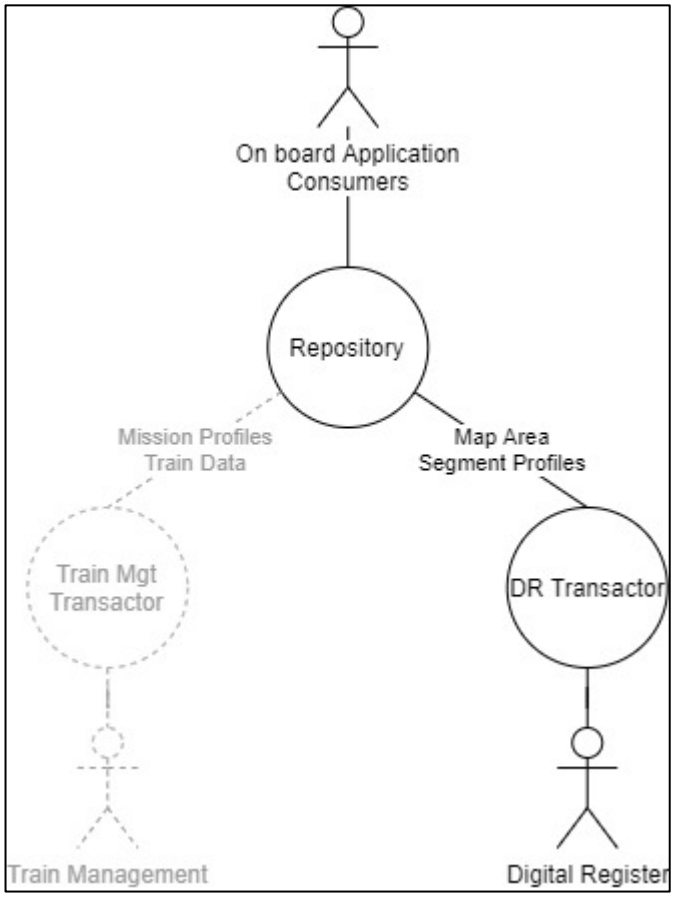

Figure 3 – Ops 1 Context diagram

4.13.3 Ops 2

4.13.3.1 In the second operational context, the train has:

- a connection established with an ATO-TS able to deliver Journey Profiles and Segment Profiles (TSI 2023 compliance)
- or equivalently a TSI 20xx or TSI 20yy compliant Traffic Mgt Transactor which is also compatible with an ATO-OB from TSI 2023, as it can still provide Journey Profiles and Segment Profiles.(See 4.12.1.10)

4.13.3.2 Possibly, there will be a Communication Session established with a Train Mgt Transactor in case the train is fit “Up to GoA4” being operated in an area fit for:

- “(TSI 2023) Up to GoA2”.

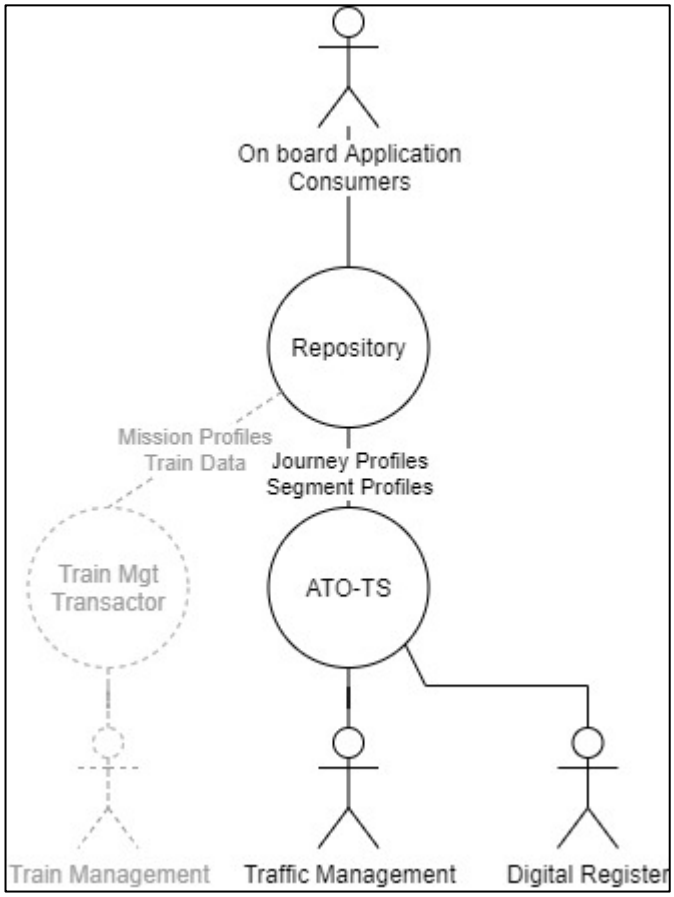

Figure 4 – Ops 2 Context diagram

4.13.4 Ops 3

4.13.4.1 In the third operational context, the train has:

- a connection established with a DR Transactor able to deliver Map Area and Segment Profiles (TSI 20xx compliance or TSI 20yy compliance);
- a connection established with a Traffic Mgt Transactor able to deliver Journey Profiles (TSI 20xx compliance or TSI 20yy compliance).

4.13.4.2 Possibly, there will be a Communication Session established with a Train Mgt Transactor in case the train is fit “Up to GoA4” being operated in an area fit for:

- “(TSI 20xx) Up to GoA2 with ASTP”.

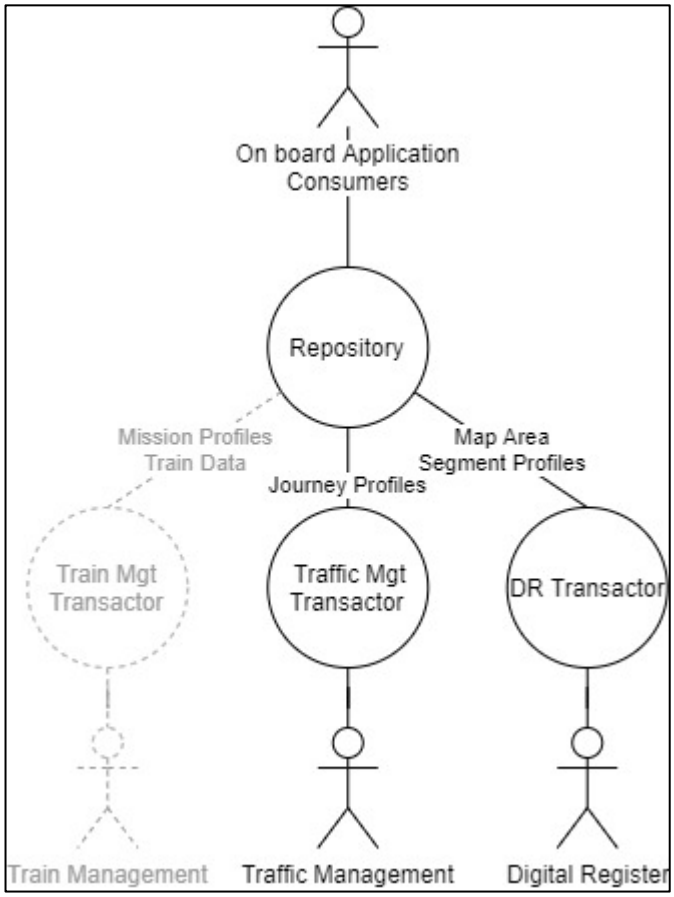

Figure 5 – Ops 3 Context diagram

4.13.5 Ops 4

4.13.5.1 In the fourth operational context, the train is mandatory connected to a Train Mgt Transactor (see Figure 6).

4.13.5.2 This will be the case when the train is fit “Up to GoA4” being operated in an area fit for:

- Up to GoA2 (TSI 2023);
- Up to GoA2 (TSI 20xx) supporting ASTP;
- Up to GoA4 (TSI 20yy) supporting ASTP

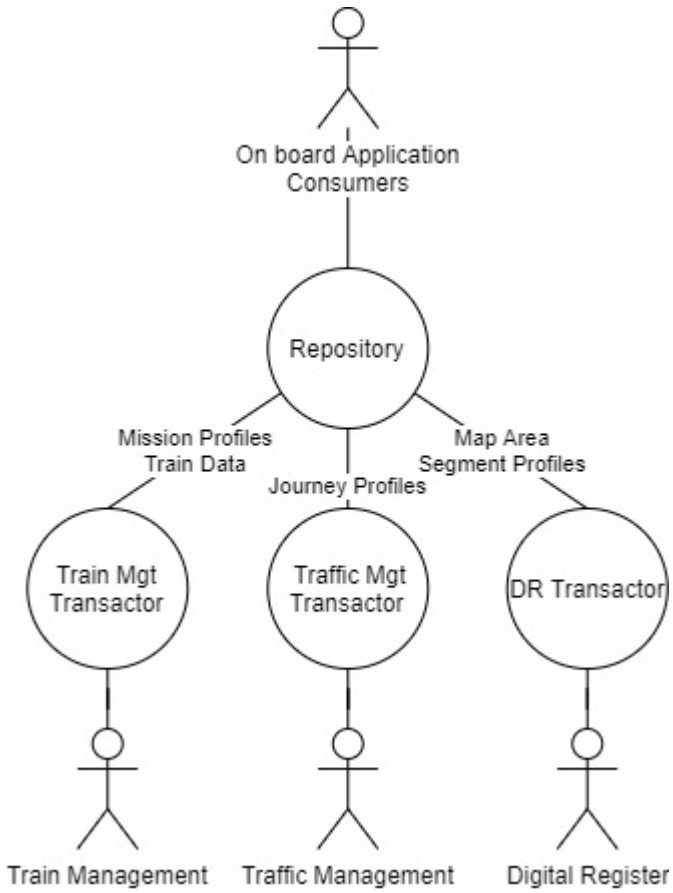

Figure 6 – Ops 3 Context diagram

5 TRACK TRAIN COMMUNICATION USE CASES

5.1 List of Use Cases

5.1.1.1 The Figure 7 gives the list of Use Cases considered.

5.1.1.2 It gives :

- the Operational Contexts in which they are applicable;
- the possible change of Operational Context which may occur due to the Use Case.

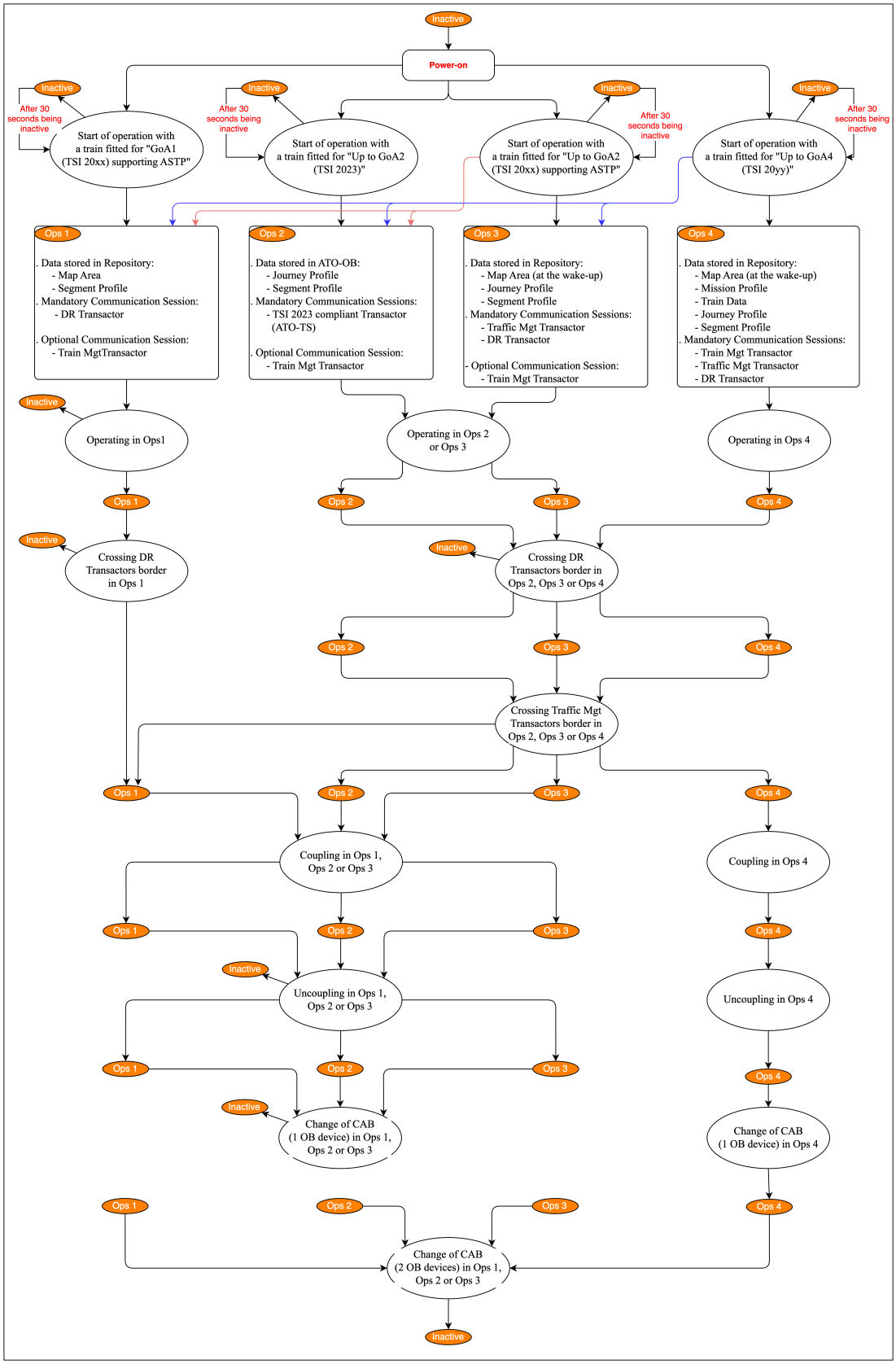

Figure 7 – Track train communication related Use Cases

5.1.1.3 Note : The Train Track Communication being in inactive state means that there is no opened communication sessions between the trackside and on-board (in the TTC principles context).

5.2 Powering-on and start of the operation

5.2.1 Introduction

5.2.1.1 As said before, the operational context depends first on train fitment:
- "(TSI 2023) Up to GoA2";
- "(TSI 20xx) Up to GoA1 with ASTP";
- "(TSI 20xx) Up to GoA2 with ASTP";
- "(TSI 20yy) Up to GoA4 with ASTP.

5.2.1.2 The operational context is determined by the Repository during the handshaking process depending on the trackside fitment.

5.2.2 Train fitted for Up to "GoA2 (TSI 2023)"

5.2.2.1 The Figure 8 describes the powering-on and operation start process for a train fitted for Up to GoA2 (TSI 2023).

5.2.2.2 In this Use Case, the ATO-OB tries to open a Communication Session using the Preconfigured Contact Information.

5.2.2.3 If the ATO-TS corresponding to the Preconfigured Contact Information is not able to provide Journey Profiles to the ATO-OB, it will reject the handshaking process giving the contact information of the appropriate ATO-TS.

5.2.2.4 Then there are 2 main alternatives.

5.2.2.5 In the first alternative, the Transactor corresponding to the ATO-TS Preconfigured Contact Information is not able to determine the Contact Information of the appropriate ATO-TS.

5.2.2.6 In this case, the ATO-OB will not be able to receive any Journey Profile or Segment Profile, the track train communication remains inactive.

5.2.2.7 In the second alternative, the Transactor corresponding to the ATO-TS Preconfigured Contact Information determines the Contact Information of the appropriate ATO-TS.

5.2.2.8 The ATO-OB opens a connection with this appropriate ATO-TS which will deliver the Journey Profiles and Segment Profiles on request

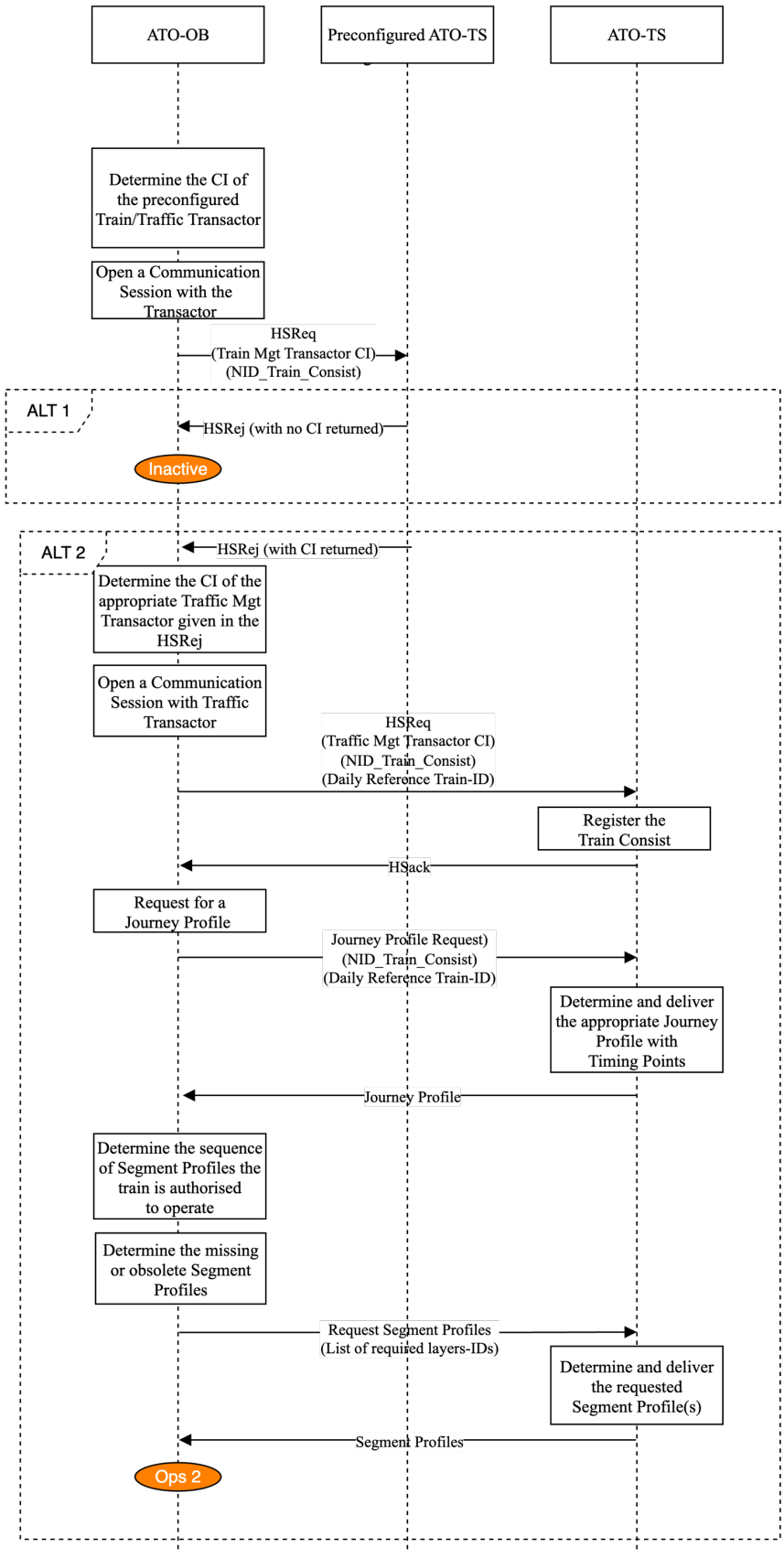

Figure 8 – Start-up of a train fitted for Up to GoA2 (TSI 2023)

5.2.2.9 In this case:
- the Communication Session is opened with the Traffic Mgt Transactor (HSAck);
- the ATO-OB sends a “Journey Profile Request” to the Traffic Mgt Transactor giving the “Daily Reference Train-ID”;
- the Traffic Mgt Transactor delivers the “Journey Profile” containing the requested Timing Points and list of Segment Profiles where the train is authorised to operate (train path);
- the ATO-OB requests from the Traffic Mgt Transactor the missing or obsolete Segment Profiles from the list of Segment Profiles listed in the Journey Profile;
- the Traffic Mgt Transactor delivers these missing or obsolete Segment Profiles;

5.2.2.10 At that stage, the train is ready to be operated in the Ops 2 context (cfr. §4.13.3).

5.2.2.11 Finally, there is another alternative which is not represented on the Figure 8. This is when the Preconfigured Train/Traffic Mgt Contact Information refers directly to a Traffic Mgt Transactor which is appropriate for this train being in its Area of Control. In this case, this Traffic Mgt Transactor will directly acknowledge the Handshaking process being able to deliver the relevant Journey Profiles.

5.2.3 Train fitted for GoA1 (TSI 20xx) supporting ASTP

5.2.3.1 The Figure 9 describes the powering-on and operation start process for a train fitted for GoA1 and supporting the ASTP on-board application.

5.2.3.2 In this Use Case, the Repository opens a Communication Session using the Preconfigured DR Transactor Contact Information (cfr. § 4.8.2).

5.2.3.3 There are 3 alternatives.

5.2.3.4 In the first alternative, the Preconfigured Contact Information gives the link to the appropriate DR Transactor.

5.2.3.5 In this case:
- the Communication Session is opened with the DR Transactor (HSAck);
- the Repository sends a “Map Area Request” to the DR Transactor giving the ID of the Segment Profiles where the train was located on when powering-off or a 3D train location;
- the DR Transactor delivers the “MAP Area” containing the list of Segment Profiles surrounding the current train location;
- the Repository request from the DR Transactor the missing or obsolete Segment Profiles;
- the DR Transactor delivers these missing or obsolete Segment Profiles;

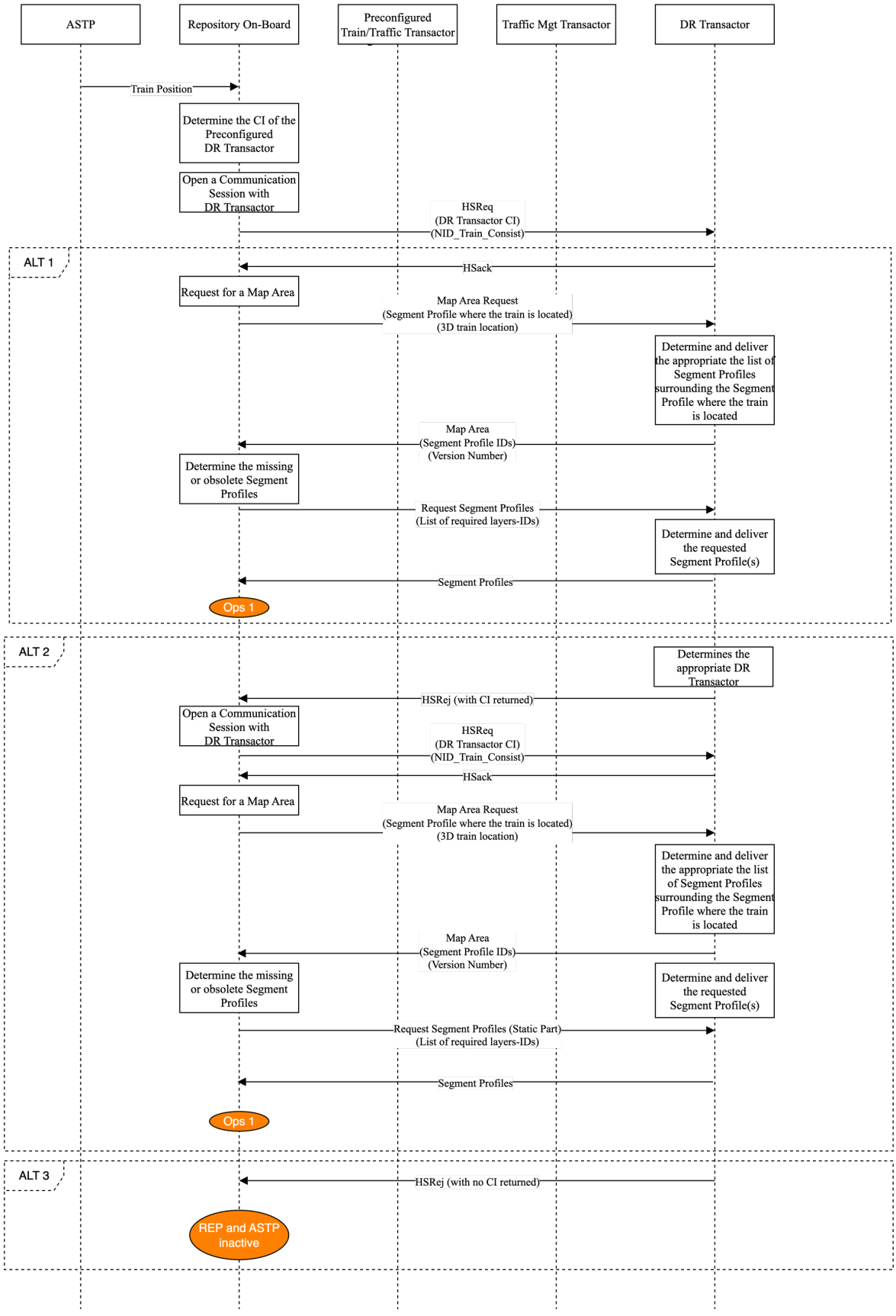

Figure 9 – Start-up of a train fitted for GoA1 (TSI 20xx) supporting ASTP

5.2.3.6 At that stage, the train is ready to be operated in the Ops 1 context (cfr. § 4.13.2).

5.2.3.7 In the second alternative, the Preconfigured Contact Information gives a link to a DR Transactor which is not appropriate in the sense that the train is not located in its Area of Control.

5.2.3.8 In this case, the DR Transactor determines the Contact Information of the appropriate DR Transactor and reject the Handshaking process giving the appropriate Contact Information.

5.2.3.9 This appropriate Contact Information is used by the Repository to open a Communication Session with the corresponding DR Transactor and to proceed as defined in the § 5.2.3.5.

5.2.3.10 In the third alternative, the Preconfigured Contact Information also gives a link to a DR Transactor which is not appropriate. And this DR Transactor is not able to provide the appropriate Contact Information when rejecting the Handshaking process.

5.2.3.11 In this case, the Repository will not be able to receive any Segment Profile.

5.2.4 Train fitted for “Up to GoA2 (TSI 20xx) supporting ASTP”

5.2.4.1 In this Use Case, the Repository tries to establish a Communication Session with a DR Transactor using the Preconfigured DR Transactor Contact information.

5.2.4.2 Once the Communication Session with a DR Transactor is established, the Repository tries to establish a Communication Session with the Traffic Mgt Transactor using the Preconfigured Train/Traffic Mgt Transactor Contact Information. This one will answer accepting the Communication Session (HSAck) or rejecting it giving the Contact Information of the Appropriate Traffic Mgt Transactor (HSRej).

5.2.4.3 Depending on the trackside fitment, there are four alternatives represented in the Figure 10.

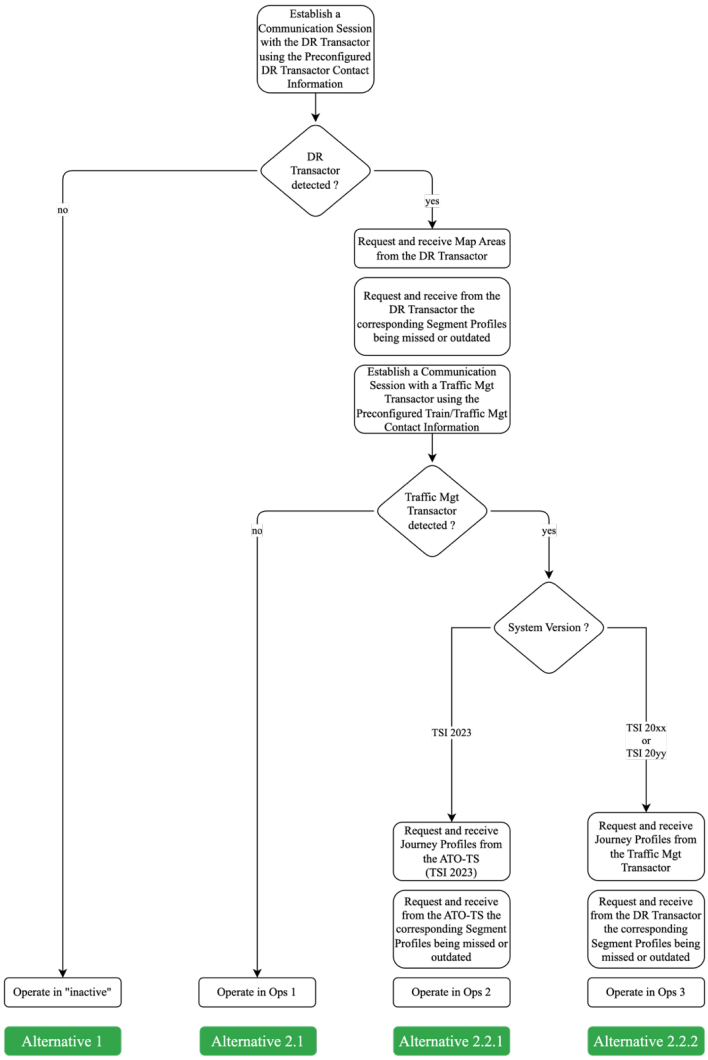

Figure 10 – Start-up of a train fitted for Up to GoA2 (TSI 20xx) supporting ASTP - alternatives

5.2.4.4 The Figure 11 describes the powering-on and operation start process for a train fitted for Up to GoA2 (TSI 20xx) supporting ASTP depending on these alternatives.

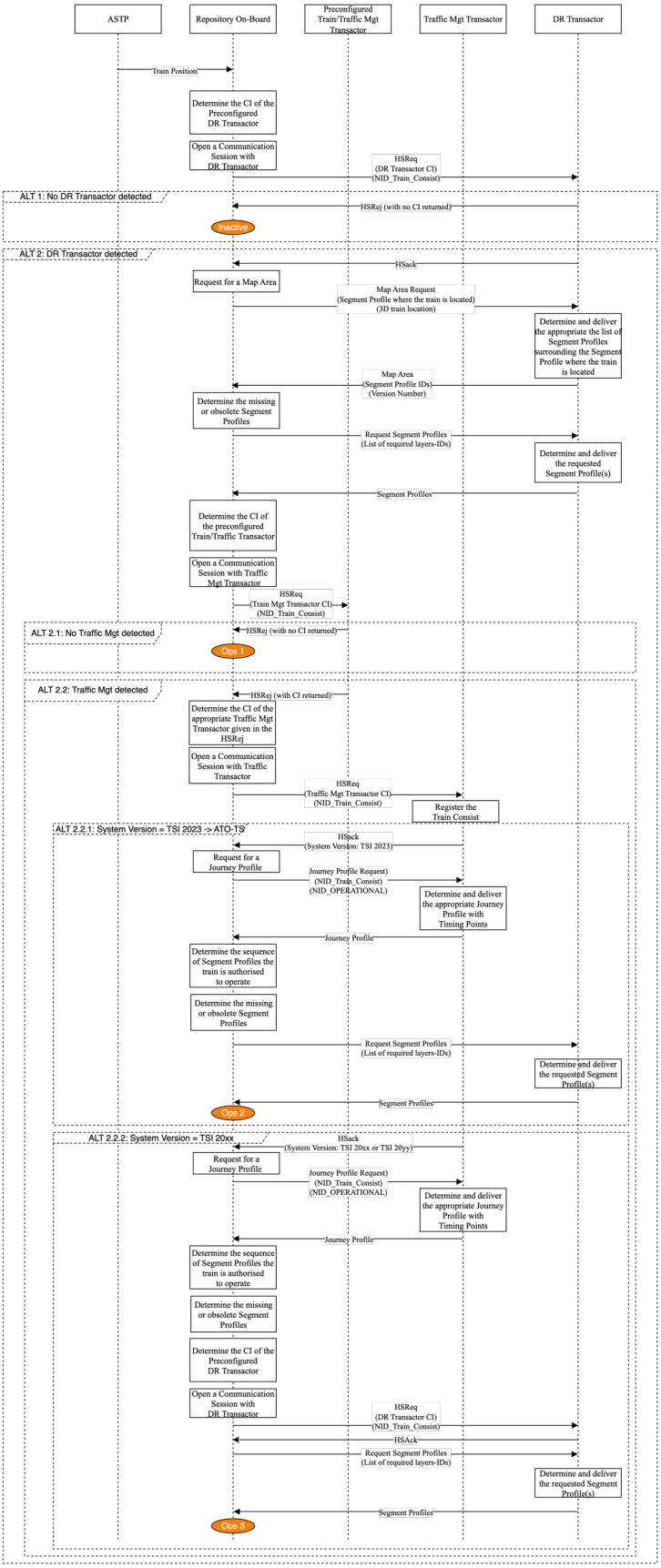

Figure 11 – Start-up of a train fitted for Up to GoA2 (TSI 20xx) supporting ASTP

5.2.5 Train fitted for Up to GoA4 (TSI 20yy) supporting ASTP

5.2.5.1 In this Use Case, the Repository establishes a Communication Session with the Train Mgt Transactor using the Preconfigured Train/Traffic Mgt Transactor Contact Information. This one will answer accepting the Communication Session (HSAck).

5.2.5.2 Once the communication session is established with Train Mgt Transactor, the Repository tries to establish a Communication Session with a DR Transactor using the Preconfigured DR Transactor Contact information.

5.2.5.3 Once the communication session is established with DR Transactor, the Repository tries to establish a Communication Session with a Traffic Mgt Transactor using the Preconfigured Train/Traffic Mgt Transactor Contact information.

5.2.5.4 Depending on the trackside fitment, there are four alternatives represented in the Figure 12.

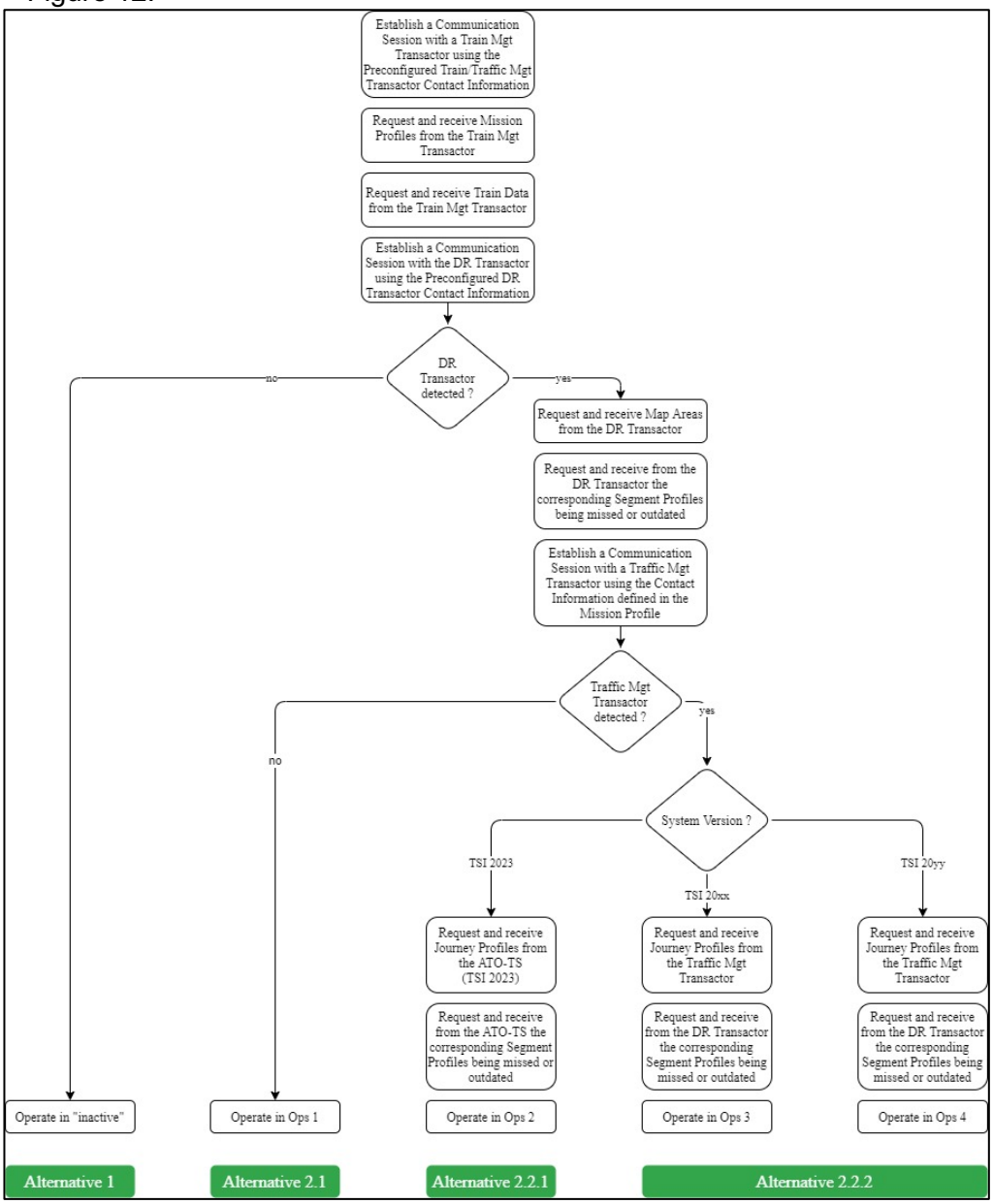

Figure 12 – Start-up of a train fitted for Up to GoA4 (TSI 20yy) - Alternatives

5.2.5.5 The Figure 13 describes the powering-on and operation start process for a train fitted for Up to GoA4 (TSI 20yy).

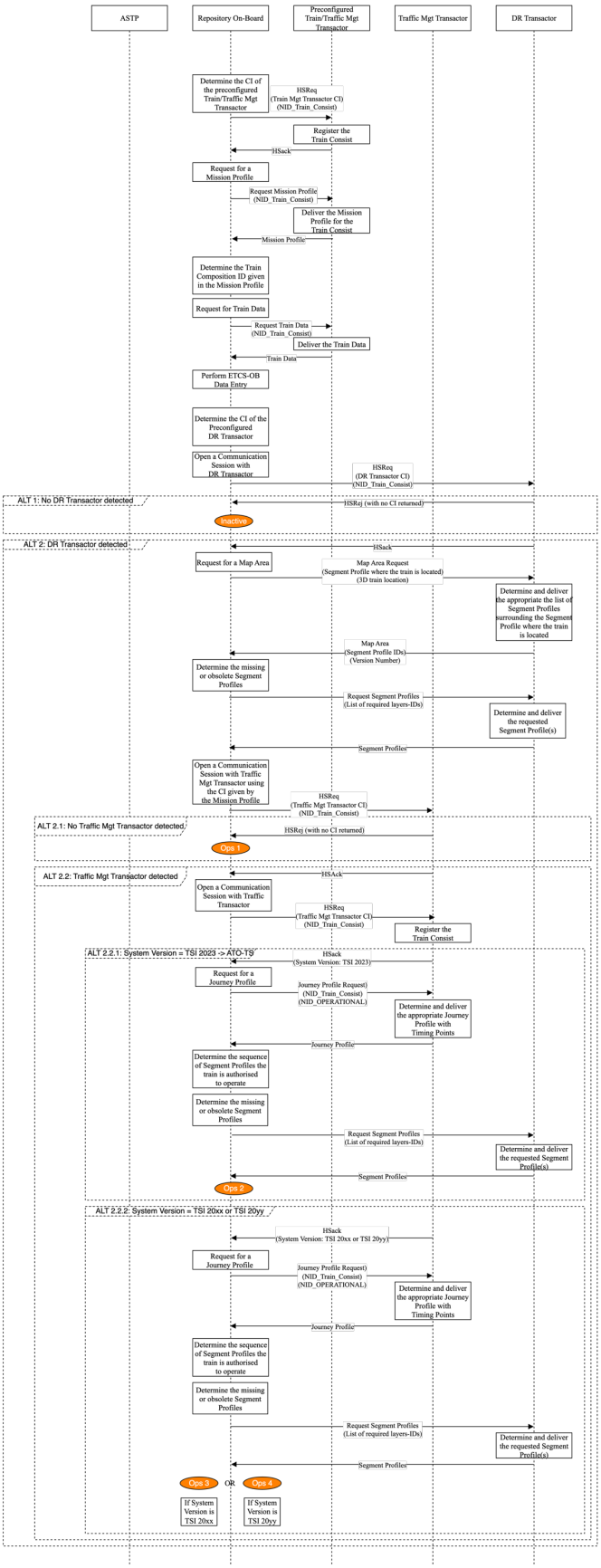

Figure 13 – Start-up of a train fitted for Up to GoA4 (TSI 20yy)

5.3 Operating in fitted" trackside area"

5.3.1 Introduction

5.3.1.1 Considering the example of a trackside area fitted according to the Figure 14.

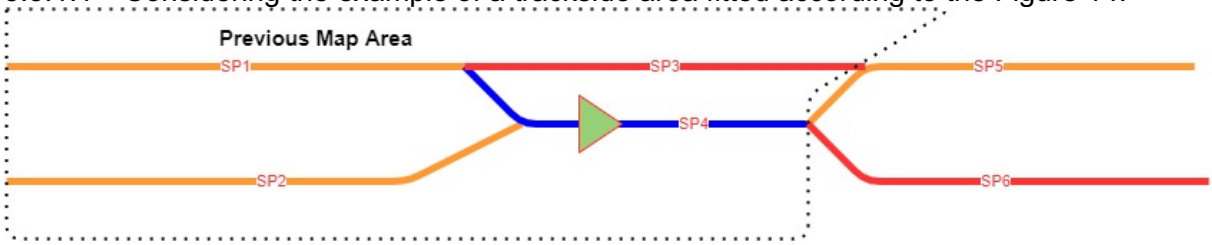

Figure 14 – Example of a fitted trackside area

5.3.1.2 In this situation, the following Segment Profiles data are defined in the Data Base of Digital Register: SP1, SP2, SP3, SP4, SP5 and SP6.

5.3.1.3 Let's suppose that:
- the Map Area previously received mentioned the SP1, SP2, SP3 and SP4;
- the current location of the train is on SP4.

5.3.1.4 In this situation, the on-board data base shall be updated with the up-coming Segment Profiles.

5.3.1.5 The behavior will be slightly different depending on the operational context:
- Ops 1;
- Ops 2;
- Ops 3;
- Ops 4.

5.3.2 Operating being in Ops 1

5.3.2.1 The Figure 15 gives the sequence diagram related to operation when being connected to a DR Transactor only.

5.3.2.2 In this situation, the Repository shall detect that the train is on a Segment Profile for which no adjacent Segment Profile has been referred in the Map Area previously transmitted.

5.3.2.3 It will request a new Map area giving the current Segment ID. And the DR Transactor will deliver a new Map Area giving the list of the IDs of Segment Profiles surrounding the Segment Profile the train is located on. In the example of Figure 14, it will be SP5 and SP6.

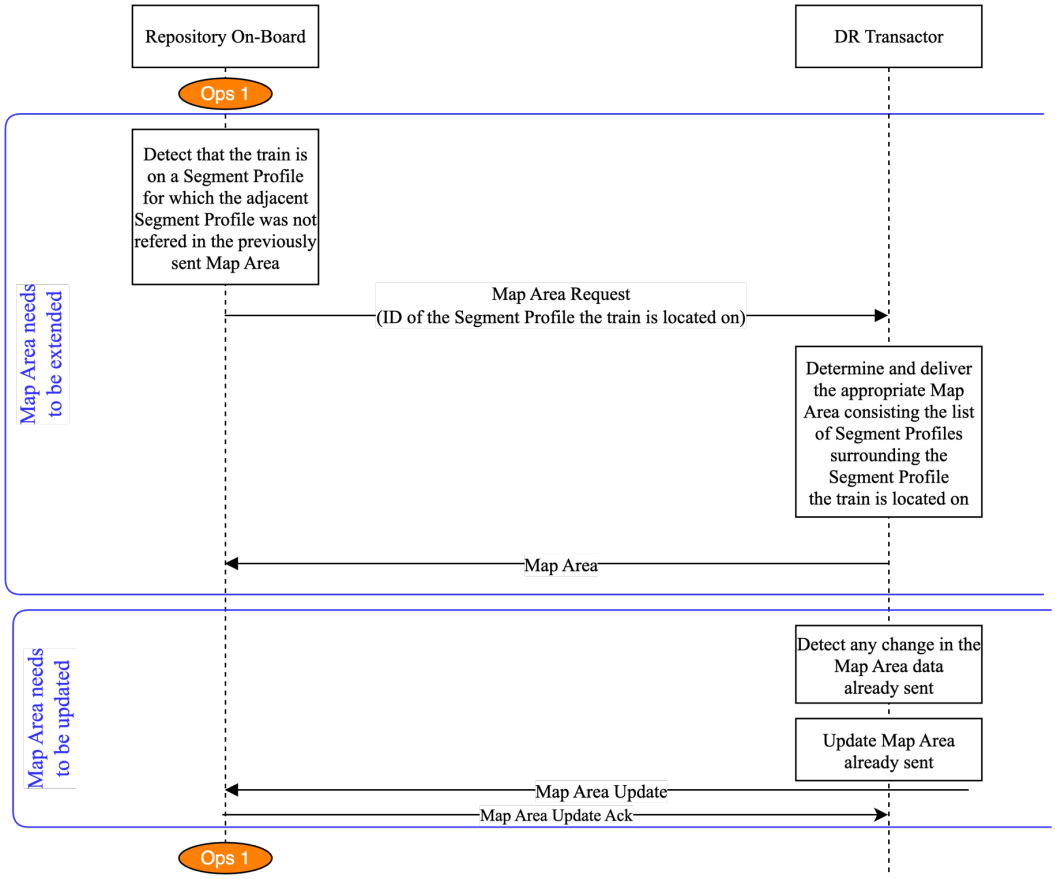

Figure 15 – Operating when being in Ops 1

5.3.2.4 Additionally, in case the DR Transactor detects that there is some change in the last Map Area already sent to the Repository, this Transactor will send a Map Area update informing the Repository about the changes.

5.3.3 Operating being in Ops 2 or Ops 3

5.3.3.1 The Figure 16 gives the sequence diagram related to operation when being in Ops 2 or in Ops 3.

5.3.3.2 In this situation, the Repository shall request for Map Area extension and receive Map Area updates as in Ops 1.

5.3.3.3 The Repository shall detect that the look ahead of the current Journey Profile needs to be extended depending on the on-board applications needs when no Timing Point is defined as “End of Journey".

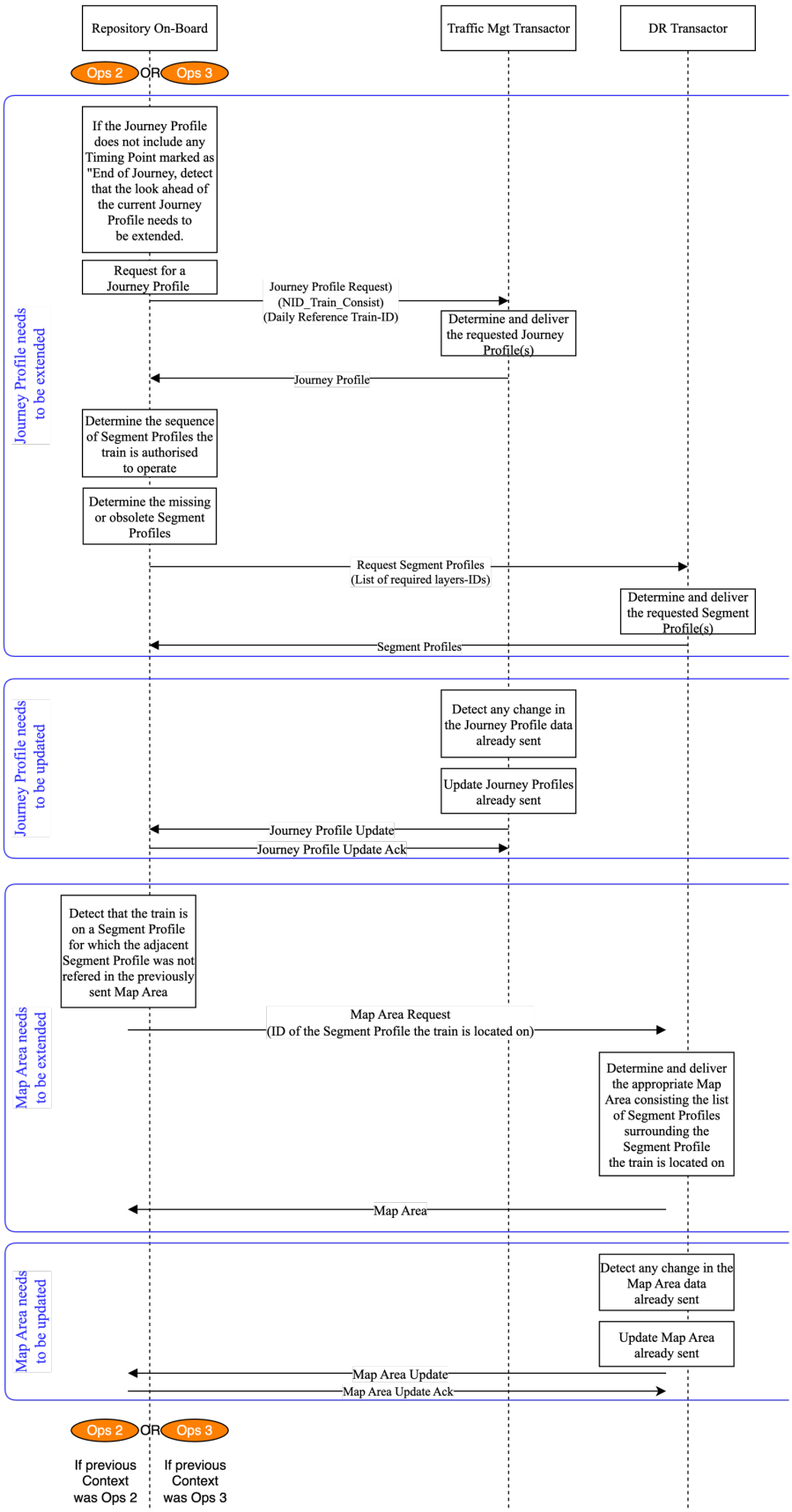

Figure 16 – Operating in Ops 2 or Ops 3

5.3.3.4 In this case, the Repository shall request JPs from the Traffic Mgt Transactor until the needed look ahead is achieved.

5.3.3.5 And the Traffic Mgt Transactor will deliver Journey Profiles extension giving new targeted Timing Points with list of the IDs of Segment Profiles covering these Timing Points. In the example of Figure 14, it will be SP5 if the selected route is going to SP5.

5.3.3.6 In addition, if there is some change related to the previously sent Journey Profile, the Traffic Mgt Transactor will send a Journey Profile Update with the updated Timing Points and the updated list of Segment Profile IDs.

5.3.3.7 A Journey Profile Update may support:
- change in Passing Time, Arrival Time and/or Departure Time;
- change in the Routes being selected.

5.3.3.8 Finally, the Repository shall also detect that the train is on a Segment Profile for which no adjacent Segment Profile has been referred in the Map Area previously transmitted.

5.3.3.9 In this case, it will request a new Map area giving the current Segment ID. And the DR Transactor will deliver a new Map Area giving the list of the IDs of Segment Profiles surrounding the Segment Profile the train is located on. In the example of Figure 14, it will be SP5 and SP6.

5.3.3.10 In case the DR Transactor detects that there is some change in the last Map Area already sent to the Repository, this Transactor will send a Map Area update informing the Repository about the changes.

5.3.4 Operating in Ops 4

5.3.4.1 The Figure 17 gives the sequence diagram related to operation when being in Ops 4.

5.3.4.2 In addition to the previous chapter 5.3.3, trains operating in Ops 4 have received a Mission Profile from the Train Mgt Transactor.

5.3.4.3 The Repository shall detect that, without being in End of Mission, the look ahead of the current Mission Profile needs to be extended depending on the on-board applications needs.

5.3.4.4 In this case, the Repository shall request Mission Profiles from the Train Mgt Transactor until the needed look ahead is achieved.

5.3.4.5 If there is some change related to the previously sent Mission Profile, the Train Mgt Transactor will send a Mission Profile Update.

5.3.4.6 In addition, the Repository shall request for Map Area extension and receive Map Area updates as in Ops 1.

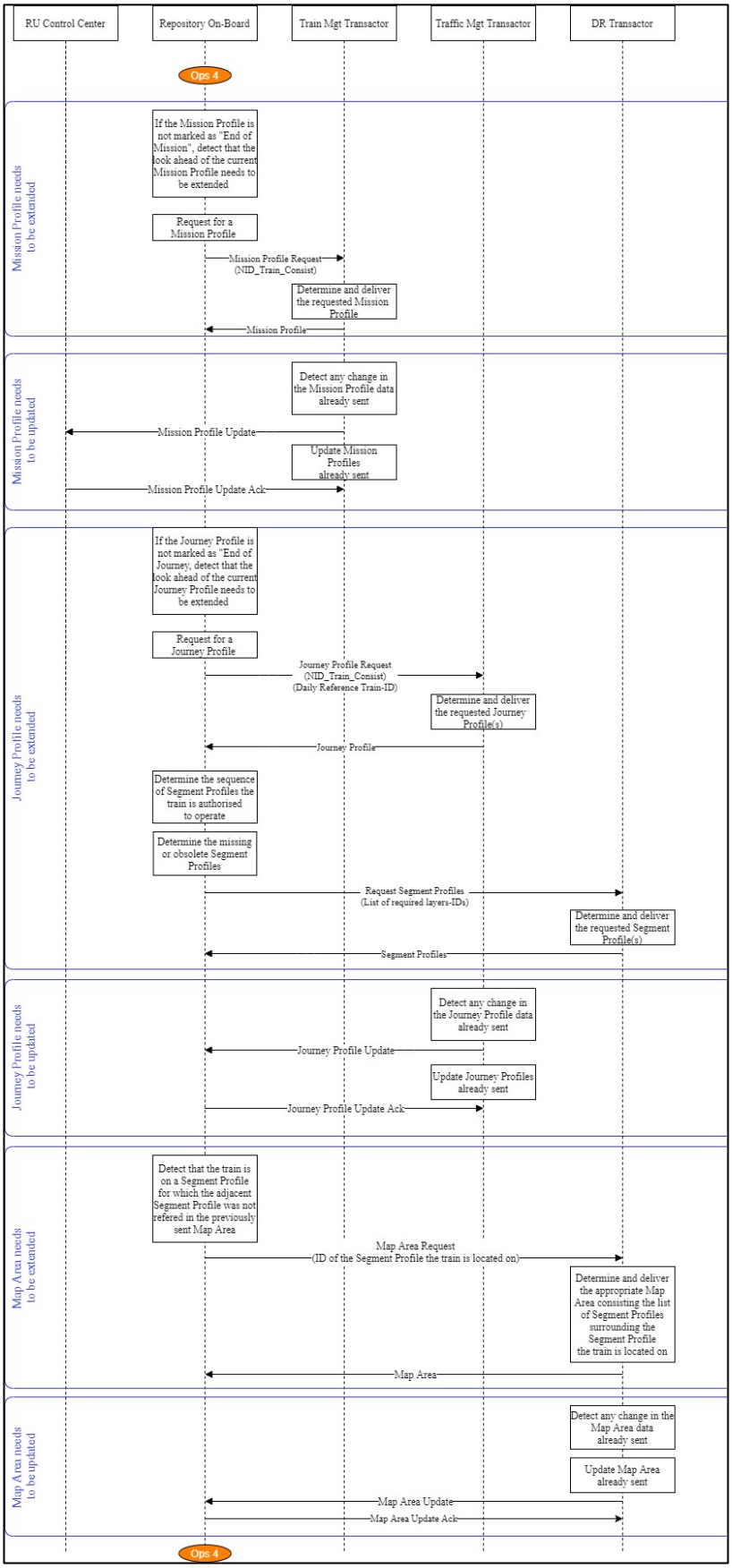
RU Control Center
Repository On-Board
Train Mgt Transactor
Traffic Mgt Transactor
DR Transactor
Ops 4
Mission Profile needs to be extended
If the Mission Profile is not marked as "End of Mission", detect that the look ahead of the current Mission Profile needs to be extended
Request for a Mission Profile
Mission Profile Request (NID_Train_Consist)
Determine and deliver the requested Mission Profile
Mission Profile
Mission Profile needs to be updated
Detect any change in the Mission Profile data already sent
Mission Profile Update
Update Mission Profiles already sent
Mission Profile Update Ack
Journey Profile needs to be extended
If the Journey Profile is not marked as "End of Journey, detect that the look ahead of the current Journey Profile needs to be extended
Request for a Journey Profile
Journey Profile Request (NID_Train_Consist) (Daily Reference Train-ID)
Determine and deliver the requested Journey Profile(s)
Journey Profile
Determine the sequence of Segment Profiles the train is authorised to operate
Determine the missing or obsolete Segment Profiles
Request Segment Profiles (List of required layers-IDs)
Determine and deliver the requested Segment Profile(s)
Segment Profiles
Journey Profile needs to be updated
Detect any change in the Journey Profile data already sent
Journey Profile Update
Update Journey Profiles already sent
Journey Profile Update Ack
Map Area needs to be extended
Detect that the train is on a Segment Profile for which the adjacent Segment Profile was not refered in the previously sent Map Area
Map Area Request (ID of the Segment Profile the train is located on)
Determine and deliver the appropriate Map Area consisting the list of Segment Profiles surrounding the Segment Profile the train is located on
Map Area
Map Area needs to be updated
Detect any change in the Map Area data already sent
Update Map Area already sent
Map Area Update
Map Area Update Ack
Ops 4

Figure 17 – Operating in Ops 4

5.4 Crossing the border of DR Transactor

5.4.1 Introduction

5.4.1.1 The behavior will be slightly different depending on the operational context:
- being in Ops 1;
- being in Ops 2, Ops 3 or Ops 4.

5.4.2 Crossing a DR Transactor border in Ops 1

5.4.2.1 The Figure 18 gives the sequence diagram related to the crossing of a border of a DR Transactors being in Ops1.

5.4.2.2 As mentioned in the clause 4.8.2.6, the Segments Profiles ending at a border of a DR Transactor contain the Contact Information of the adjacent DR Transactor (if any). This permits to open a communication session with the “accepting” DR Transactor (if any) when approaching the border.

5.4.2.3 When the train is located on a Segment Profile the end of which is at the border of the Area of Control of the DR Transactor, the Repository checks if the Segment Profile data mentions the Contact Information of an adjacent DR Transactor.

5.4.2.4 If it is not the case, as soon as the head of the train reaches the DR Transactor border (Alternative 1 in the Figure 18), the Repository will become inactive and the ASTP application will only work on basic level (i.e. without information coming from any DR transactor).

5.4.2.5 When the Segment Profile data gives the Contact Information of an adjacent DR Transactor (alternative 2), the Repository will open a communication session with the Accepting Transactor (handshaking process).

5.4.2.6 Note : There is at most one Contact Information of an adjacent DR Transactor per Segment Profile. However, there can be several border Segment Profiles each having potentially different Contact Information. In which case, the Repository opens a communication with each different DR Transactor.

5.4.2.7 When the Communication Session is opened, the Repository is sending a Map Area Request giving the ID of the Segment Profile the train is located on (Segment Profile Reference ID).

5.4.2.8 The Accepting DR Transactor:
- determines the list of Segment Profiles located around the border with the given Segment Profile Reference;
- sends the corresponding Map Area to the Repository.

5.4.2.9 The Repository on-board determines the list of Segment Profiles which are missing or the version of which is obsolete.

5.4.2.10 For these missing or obsolete Segment Profiles, it sends Segment Profiles requests to the DR Transactor which sends back the up-to-date version of these Segment Profiles.

5.4.2.11 At that moment, the Repository has two Communication Sessions opened with the "Handing over DR Transactor" and with the "Accepting DR Transactor" respectively.

5.4.2.12 The Repository shall request the termination of Communication Session Termination with the "Handing over DR Transactor" as soon as the train has completely left the area controlled by this Transactor. This means as soon as the train has left the so-called Segment Profile Reference.

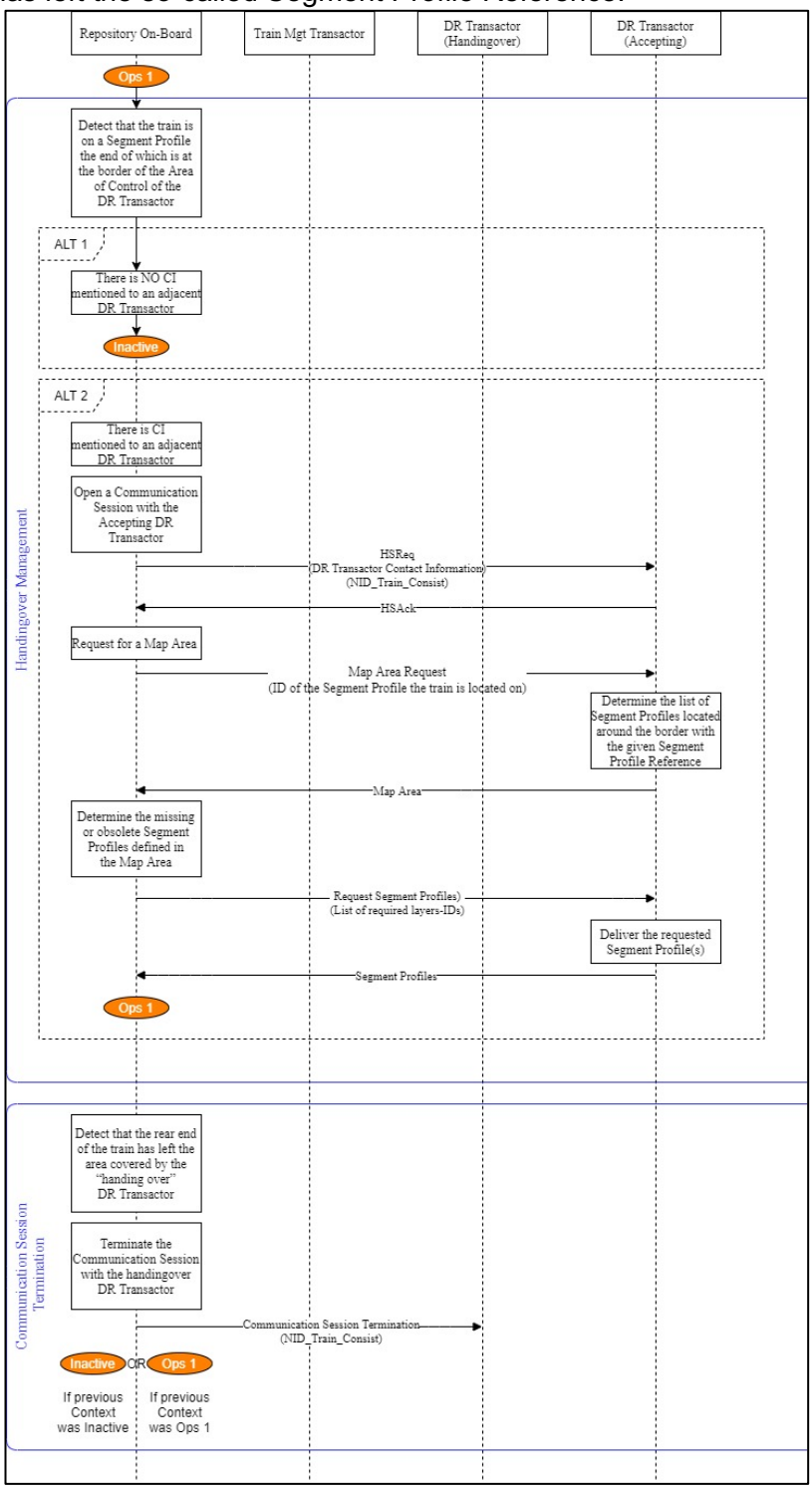

Figure 18 – Crossing a DR Transactor border Ops 1

5.4.3 Crossing a DR Transactor border in Ops 2, Ops 3 or Ops 4

5.4.3.1 The Figure 19 gives the sequence diagram related to the crossing of a DR Transactor border being in operation contexts Ops 2, Ops 3 or Ops 4.

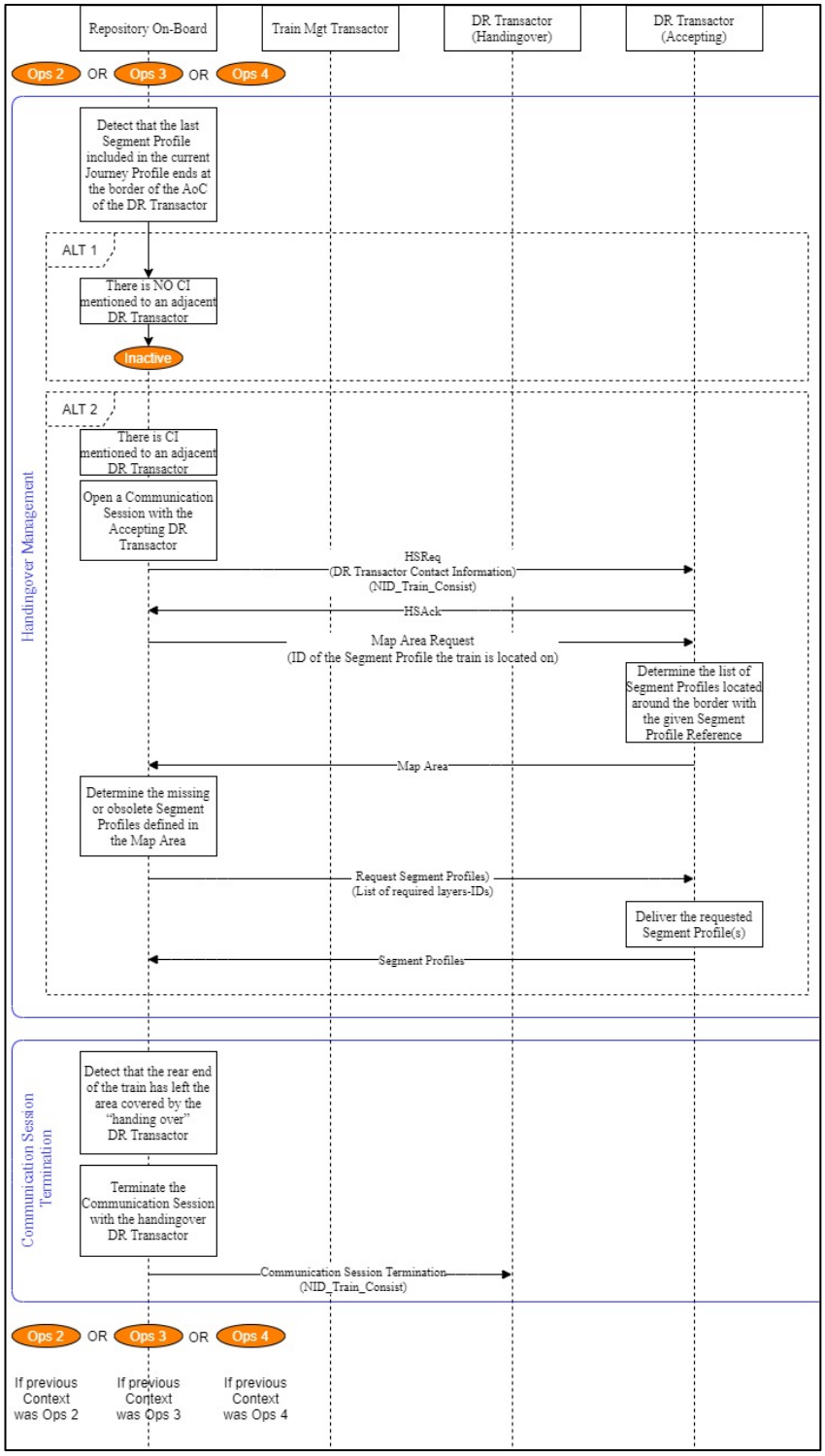

Figure 19 – Crossing a border between 2 DR Transactors in Ops 2, 3 or 4

5.4.3.2 In this Use Case, the last Segment Profile in the current Journey Profile / Map Area contains the Contact Information related to an adjacent DR Transactor (if any).

5.4.3.3 When the last Segment Profile included in the current Journey Profile / Map Area ends at the border of the Area of Control of the DR Transactor, the Repository checks if the Segment Profile data mentions the Contact Information of an adjacent DR Transactor.

5.4.3.4 If it is not the case, as soon as the head of the train reaches the DR Transactor border (Alternative 1 in the Figure 19), the Repository will become inactive and the ASTP application will only work on basic level (i.e. without information coming from any DR transactor).

5.4.3.5 When the Segment Profile data gives the Contact Information of an adjacent DR Transactor (alternative 2), the Repository will open a communication session with the Accepting Transactor which will be ready to deliver the requested Segment Profile when needed (extension of the Journey Profile look ahead).

5.4.3.6 The Repository will terminate the Communication Session with the “Handing-over” DR Transactor when the rear end of the train will have left the last Segment Profile which is in the Area of Control of this Handing-over DR Transactor.

5.5 Crossing a "trackside area border of a Traffic Mgt Transactors"

5.5.1 Introduction

5.5.1.1 By definition, this Use Case makes sense only when there is a Communication Session established with a Traffic Mgt Transactor; meaning in Ops 2, Ops 3 or Ops 4.

5.5.1.2 The same Use Case is applicable for these three Operation Contexts.

5.5.2 Crossing a Traffic Mgt border being in Ops 2, Ops 3 or Ops 4

5.5.2.1 The Figure 20 gives the sequence diagram related to the crossing of a border of a Traffic Mgt Transactor.

5.5.2.2 As mentioned in the clause 4.8.3.4, the segments Profiles ending at a border between two Traffic Mgt Transactors contain the Contact Information of the adjacent Traffic Mgt Transactor (if any). This permits to open a communication session with the “accepting” Traffic Mgt Transactor (if any) when approaching the border.

5.5.2.3 When the last Segment Profile of the current Journey Profile ends at the border of the Area of Control of the Traffic Mgt Transactor, the Repository checks if the Segment Profile data mentions the Contact Information of an adjacent Traffic Mgt Transactor.

5.5.2.4 If it is not the case, the Repository will request and receive a Map Area from the connected DR Transactor. And it will continue the operation in Ops 1 without Traffic Mgt Transactor (Alternative 1 in the Figure 20).

5.5.2.5 When the last Segment Profile referred in the previously received Journey Profile

contains the Contact Information of an adjacent Traffic Mgt Transactor (alternative 2 in Figure 20), the Repository will open a communication session with the Accepting Transactor (handshaking process).

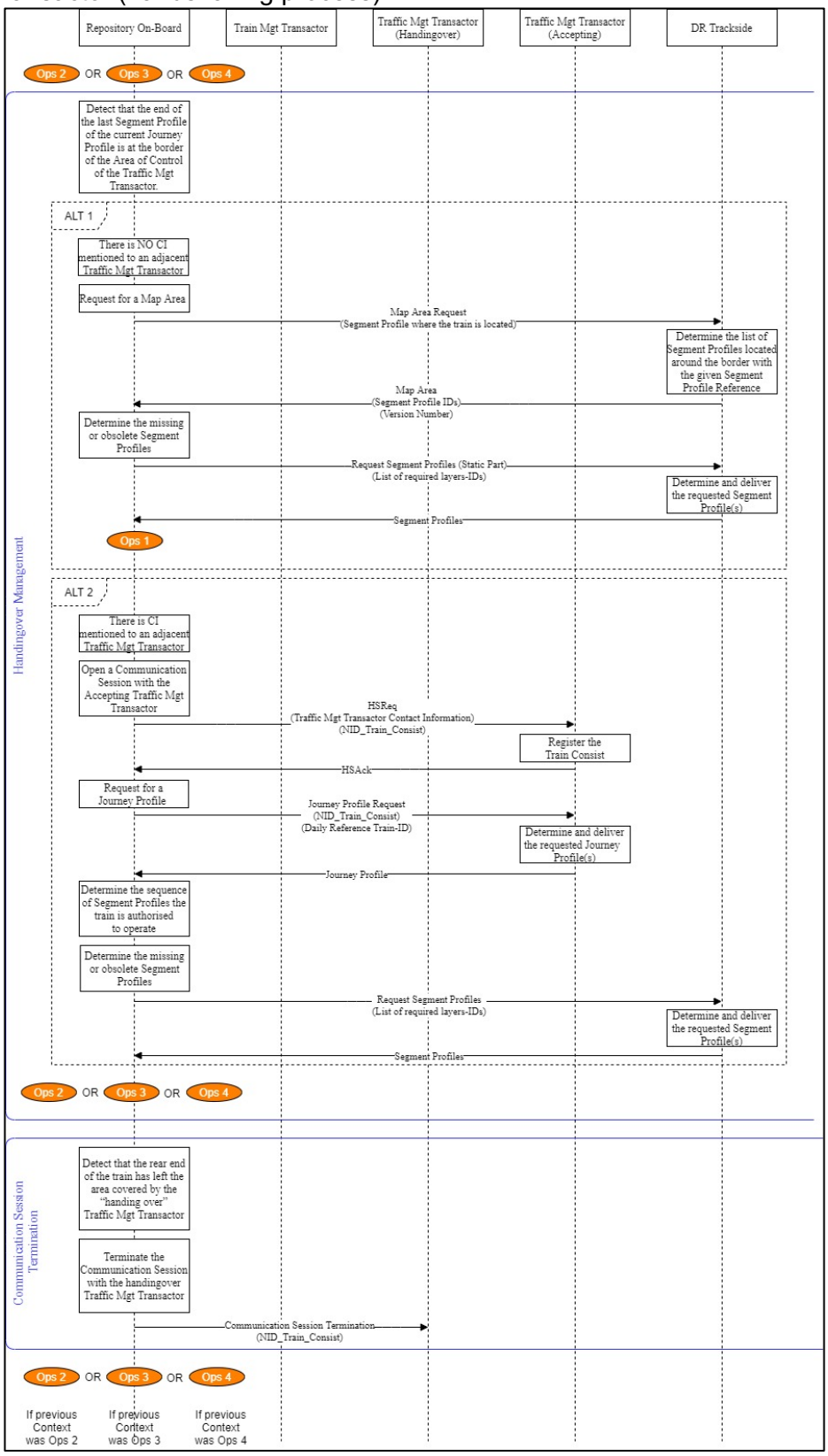

Figure 20 – Crossing a Traffic Mgt Transactor border

5.5.2.6 When the Communication Session is opened, the Repository is sending a Journey Profile Request with an additional parameter which is giving the ID of the Segment Profile the train is located on (Segment Profile Reference ID).

5.5.2.7 The Accepting Traffic Mgt Transactor sends back a Journey Profile giving
- the Timing Points associated to the Daily Reference Train-ID with the expected passing times, arrival times and departure times;
- the list of Segment Profile IDs associated to the train path.

5.5.2.8 The Repository on-board determines the list of Segment Profiles which are missing or the version of which is obsolete.

5.5.2.9 For these missing or obsolete Segment Profiles, it sends Segment Profiles requests to the DR Transactor (or the Accepting DR Transactor if any) which sends back the up-to-date version of these Segment Profiles.

5.5.2.10 At that moment, the Repository has two Communication Sessions opened with the "Handing over Traffic Mgt Transactor" and with the "Accepting Traffic Mgt Transactor" respectively.

5.5.2.11 The Repository shall request the termination of Communication Session Termination with the "Handing over Traffic Mgt Transactor" as soon as the train has completely left the area controlled by this Transactor. This means as soon as the train has left the so-called Segment Profile Reference.

5.6 Coupling two Train Consists

5.6.1 Introduction

5.6.1.1 The behaviour will be different depending on the operational context:
- Ops 1, Ops 2 or Ops 3
- Ops 4.

5.6.2 Coupling in Ops 1, Ops 2 or Ops 3

5.6.2.1 In these operational contexts, the coupling is managed by the driver and, possibly, trackside staff.

5.6.2.2 From the track train communication point of view, the “LEADING” train consist (after coupling) will keep the active Communication Sessions open depending on the current Operational Context (see Figure 21). A contrario, the “NON LEADING” train consist will close the opened communication sessions when the corresponding cab has been closed.

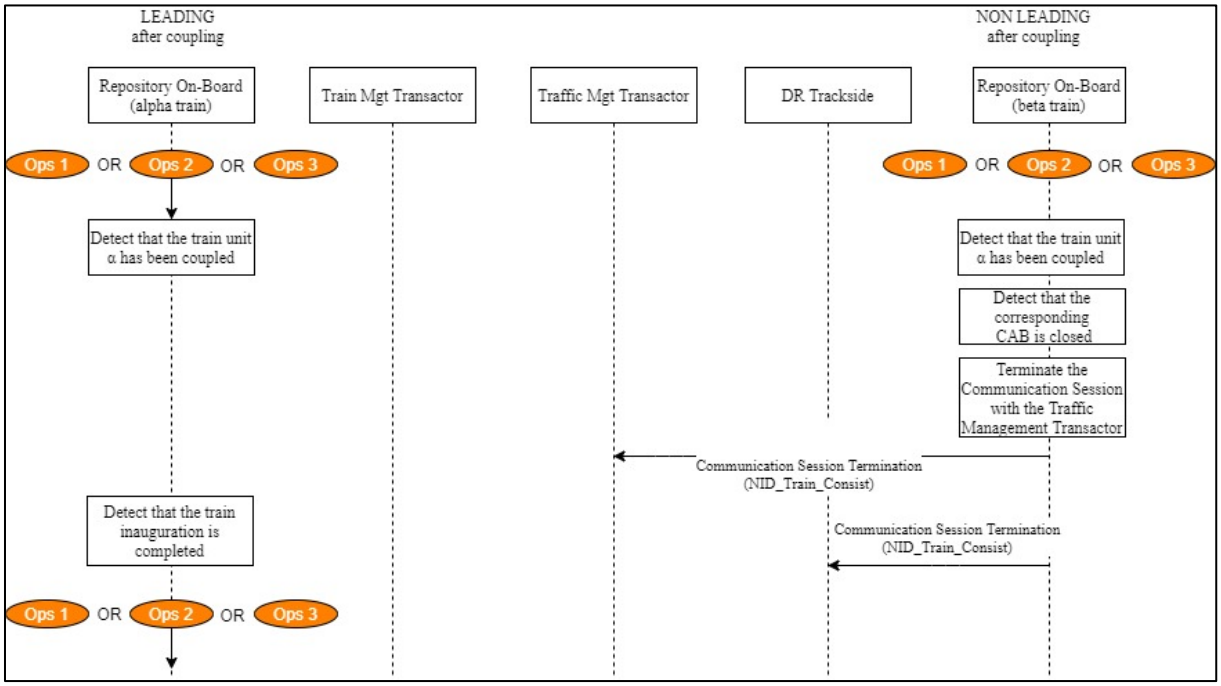

Figure 21 – Coupling 2 Train Consists in Ops 1, Ops 2 or Ops 3

5.6.2.3 The “LEADING” train consist will continue the operation according to the Operational Context applicable previously before the coupling.

5.6.3 Coupling in Ops 4

5.6.3.1 When the 2 Train Consists are operated in the operational context Ops 4, the closing and opening of the relevant cabs are performed automatically based on the information given by the Mission Profiles.

5.6.3.2 Each Train Consist has its own Mission Profile delivered by their respective Train Mgt Transactor.

5.6.3.3 These Mission Profiles determine:
- which Train Consist will be the “LEADER” and which one will be the “FOLLOWER”;
- which is the “Train Composition ID”;
- which is the “Daily Reference Train-ID” of the coupled train.

5.6.3.4 The Contact Information of the DR Transactor and of the Traffic Mgt Transactor are stored and kept from the previous trip. The Repository of the “FOLLOWER” Train Consist shall close the Communication Sessions with the Traffic Mgt Transactor and with the DR Transactor.

5.6.3.5 The connections of the Repository of the “LEADER” remain actives. Consequently, the current Map Area remains valid.

5.6.3.6 The Repository of the “LEADER” shall:
- request and receives the Train Data set corresponding to the “Train Composition ID”;
- request and receives the Journey Profile corresponding to the Daily Reference Train-ID;
- request and receives the missing or obsolete Segment Profiles.

5.6.3.7 The Figure 22 gives the corresponding sequence diagram.

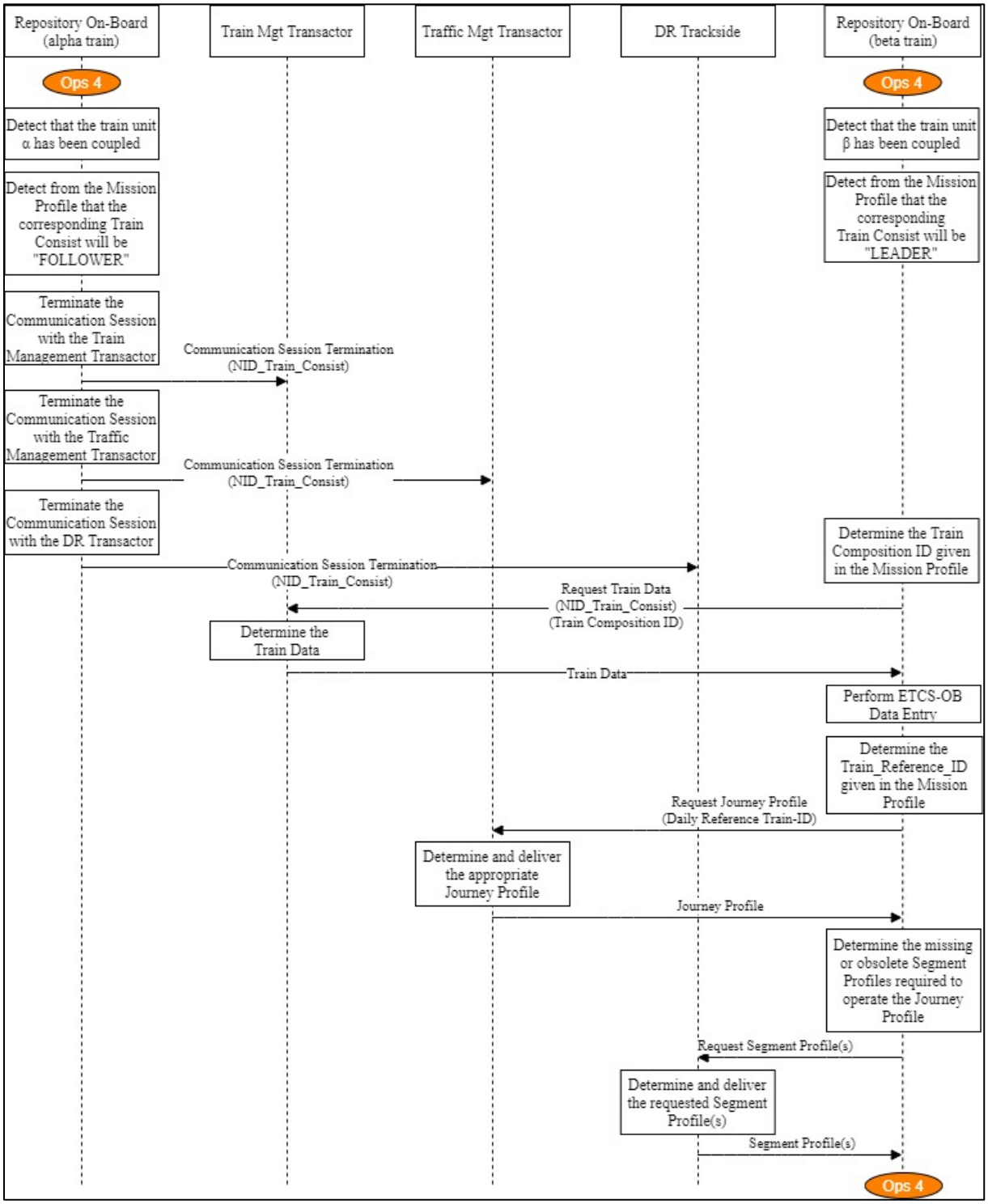

Figure 22 – Coupling 2 Train Consists in Ops 4

5.7 Uncoupling a train

5.7.1 Introduction

5.7.1.1 The behaviour will be different depending on the operational context:
- Ops 1, Ops 2 or Ops 3
- Ops 4.

5.7.2 Uncoupling in Ops 1, Ops 2 or Ops 3

5.7.2.1 In these operational contexts, the uncoupling is managed by the driver and, possibly, trackside staff.

5.7.2.2 After the uncoupling, the train consist which previously led the train will keep the active Communication Sessions open depending on the current Operational Context (see, Figure 23).

5.7.2.3 The train consist which was “NOT LEADING” the train will start the operation according to the current Operational Context.

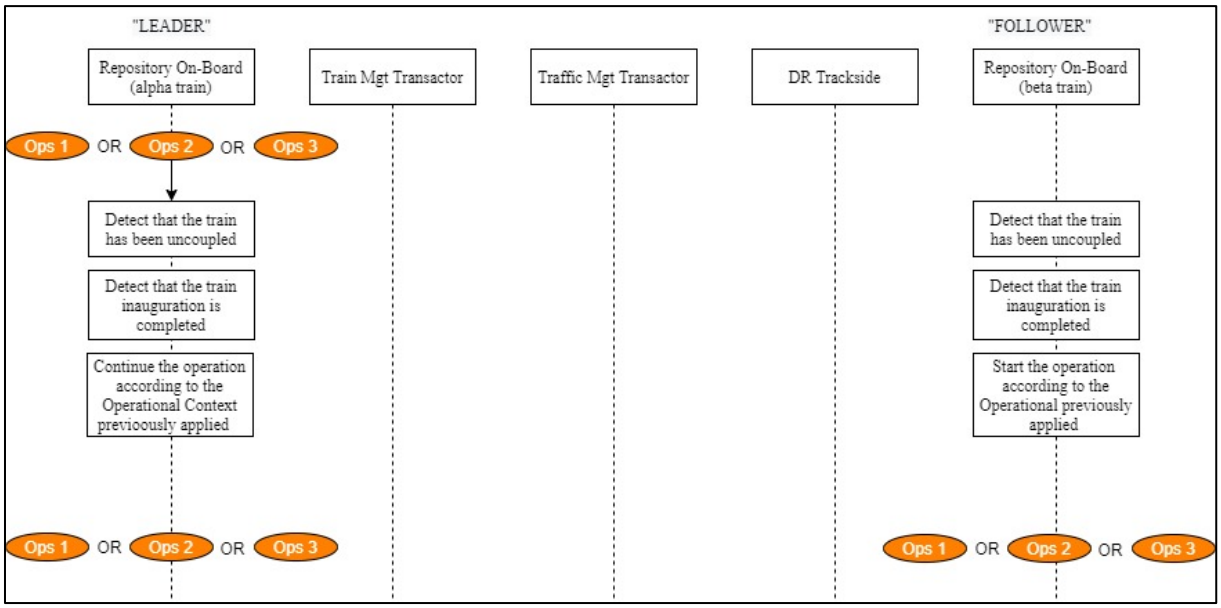

Figure 23 – Uncoupling a Train in Ops 1, Ops 2 or Ops 3

5.7.3 Uncoupling in Ops 4

5.7.3.1 When a train is uncoupled being in operational context Ops 4, the opening of the relevant cab in both Train Consists is performed automatically based on the information given by the Mission Profiles and in the Journey Profile.

5.7.3.2 Each Train Consist has its own Mission Profile delivered by their respective Train Mgt Transactor before the uncoupling occurs.

5.7.3.3 These Mission Profiles determine:
- which is the “Train Composition ID”;

- which is the “Daily Reference Train-ID” of the coupled Train Consists;

5.7.3.4 It is assumed that the Train Consist which was the “LEADER” one, maintain the Communication Session with the DR Transactor and with the Traffic Mgt Transactor opened while the “FOLLOWER” one must open a Communication Session with:
- the DR Transactor using the Preconfigured DR Transactor Contact Information;
- and with the Traffic Mgt Transactor mentioned in its Mission Profile.

5.7.3.5 The Repository of the Train Consist which was the LEADER shall:
- request and receive the Train Data set corresponding to the “Train Composition ID”;
- request and receive the Journey Profile corresponding to the Daily Reference Train-ID;
- request and receive the missing or obsolete Segment Profiles from the list associated to the Journey Profile.

5.7.3.6 The Repository of the Train Consist which was the FOLLOWER shall:
- request and receive the Train Data set corresponding to the “Train Composition ID”;
- open a Communication Session with the DR Transactor;
- open a communication session with the Traffic Mgt Transactor;
- request and receive the Map Area and corresponding Segment Profiles;
- request and receive the Journey Profile corresponding to the Daily Reference Train-ID;
- request and receive the missing or obsolete Segment Profiles from the list associated to the Segment Profile.

5.7.3.7 The Figure 24 gives the corresponding sequence diagram.

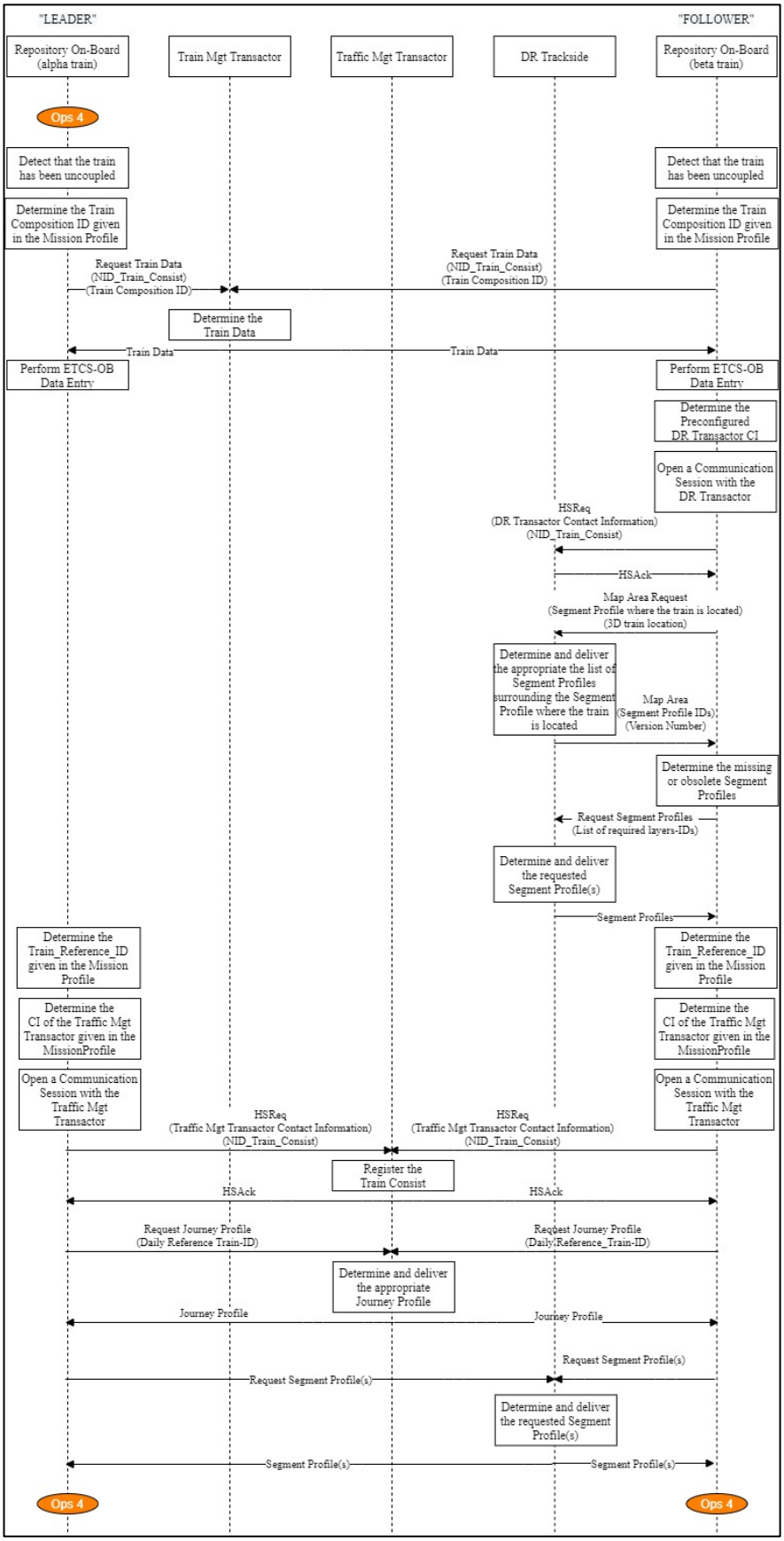

Figure 24 – Uncoupling a Train in Ops 4

5.8 Change of cab (1 OB device in 1 traction Unit)

5.8.1 Introduction

5.8.1.1 The behavior will be different depending on the operational context:
- Ops 1, Ops 2 or Ops 3
- Ops 4.

5.8.2 Change of cab (1 OB device) in Ops 1, Ops, 2 or Ops 3

5.8.2.1 When is operated in one of these operational contexts, the change of cab of a Train is managed as the Use Case related to the powering on of the train (see Chapter 5.2).

5.8.2.2 The driver shall close its current cab, go to the other cab, open the other cab and shall perform the process of Start of Mission.

5.8.2.3 This use case is identical to the one related to the powering on.

5.8.3 Change of cab (1 OB device) in Ops 4

5.8.3.1 When the train is operated in the operational context Ops 4, the change of cab is performed automatically based on the information given:
- In the Mission Profile: the new Daily Reference Train-ID;
- In the Segment Profile the train is located on: the nominal direction;
- Journey Profile: the operational direction.

5.8.3.2 The Figure 25 gives the sequence diagram related to change of cab being in Ops 4.

5.8.3.3 The current cab is closed, and the other cab is opened performing automatically the SoM Process.

5.8.3.4 In this case, since we are considered that there is only one OB device, the connections to Repository are assumed remaining active. Consequently, the current Map Area remains valid.

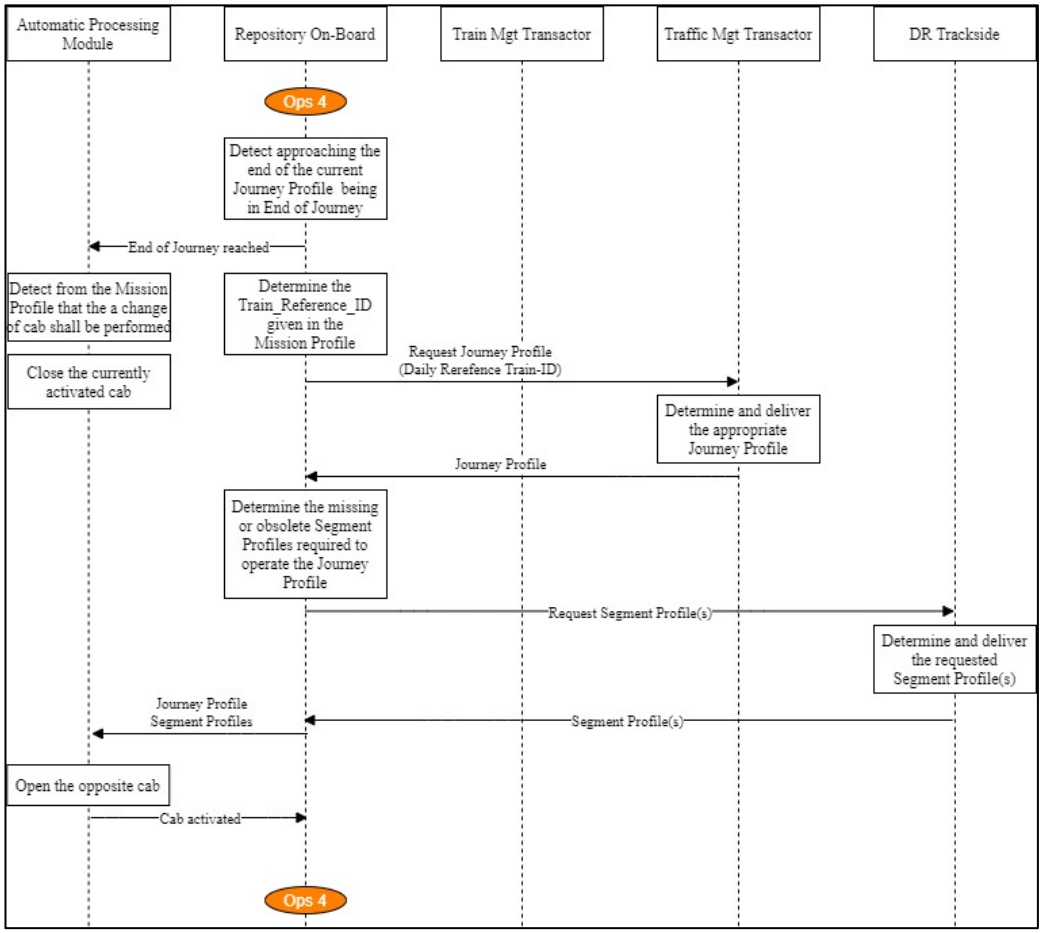

Figure 25 – Change of cab (1 OB device) in Ops 4

5.9 Change of cab (2 OB devices in 2 traction Units)

5.9.1.1 In case there are two on-board devices, the change of cab is always done manually in the same way it is specified in the Chapter 5.2.

5.10 Change of RU

5.10.1.1 It may happen that there is a transfer of responsibility from one RU to another at a given location on the track. In this case, the Train Mgt Transactor will also be different.

5.10.1.2 There is a dedicated task in the Mission Profile indicating this change of responsibility and giving the Contact Information of the “Accepting Train Mgt Transactor”.

5.10.1.3 As soon as the current Mission Profile mentions a task related to a change of RU, the Repository opens a new Communication Session with the “Accepting Train Mgt Transactor”.

5.10.1.4 When the Communication Session is established with the “Accepting Train Mgt Transactor, the Repository requests for a Mission Profile extension (MPReq). And, the “Accepting Train Mgt Transactor” sends the Mission Profile to the Repository.

5.10.1.5 When the front of the train has passed the location where the RU responsibility is changing, the Repository terminates the communication session with the handing over Train Mgt Transactor.

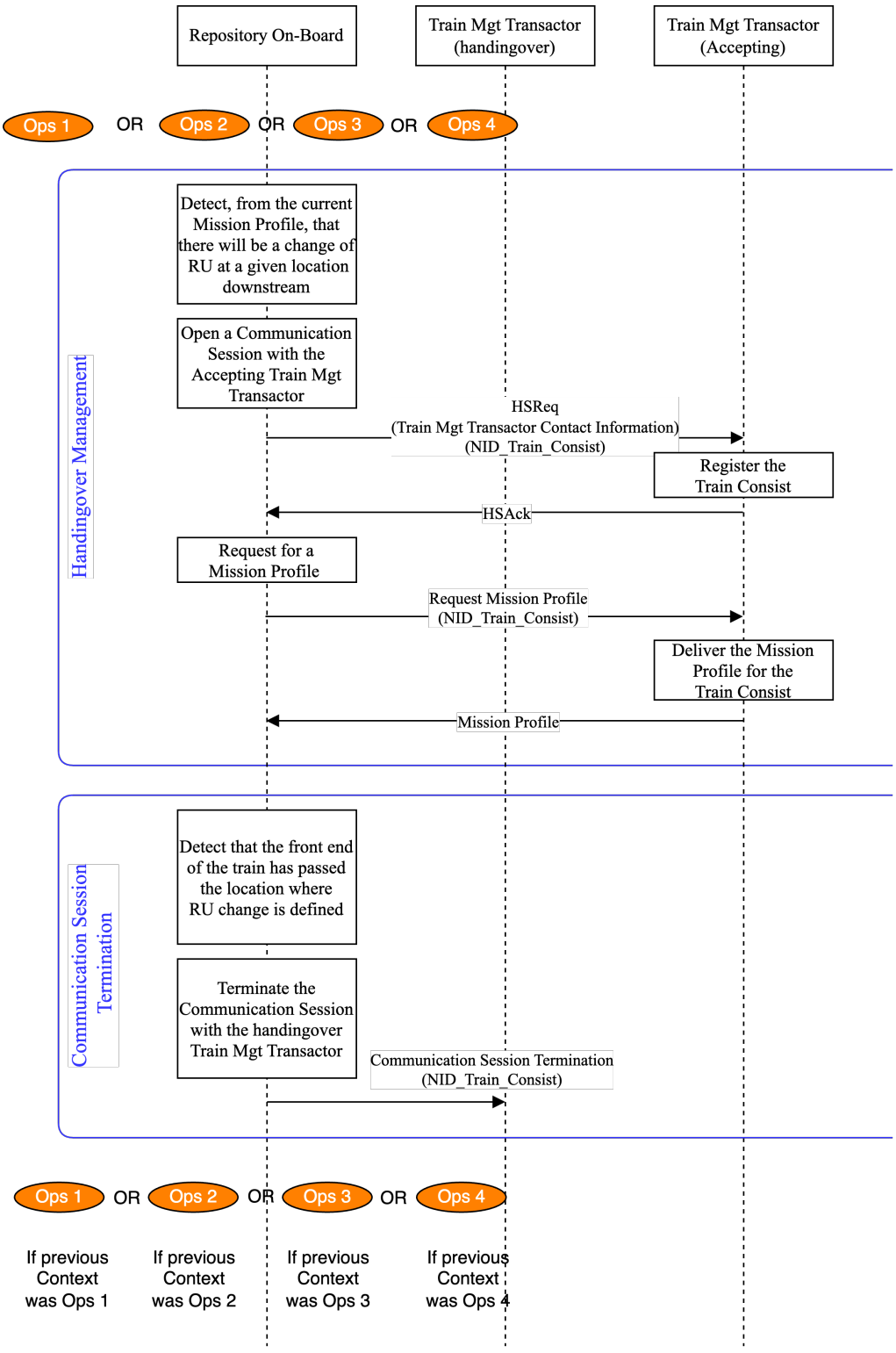

Figure 26 – RU Change

6 LOGICAL ARCHITECTURE

This chapter defines the allocation of the all the functions defined in the sequence diagrams in chapters 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 5.10 to the logical architecture variants of different operational scenarios.

6.1 Ops 1

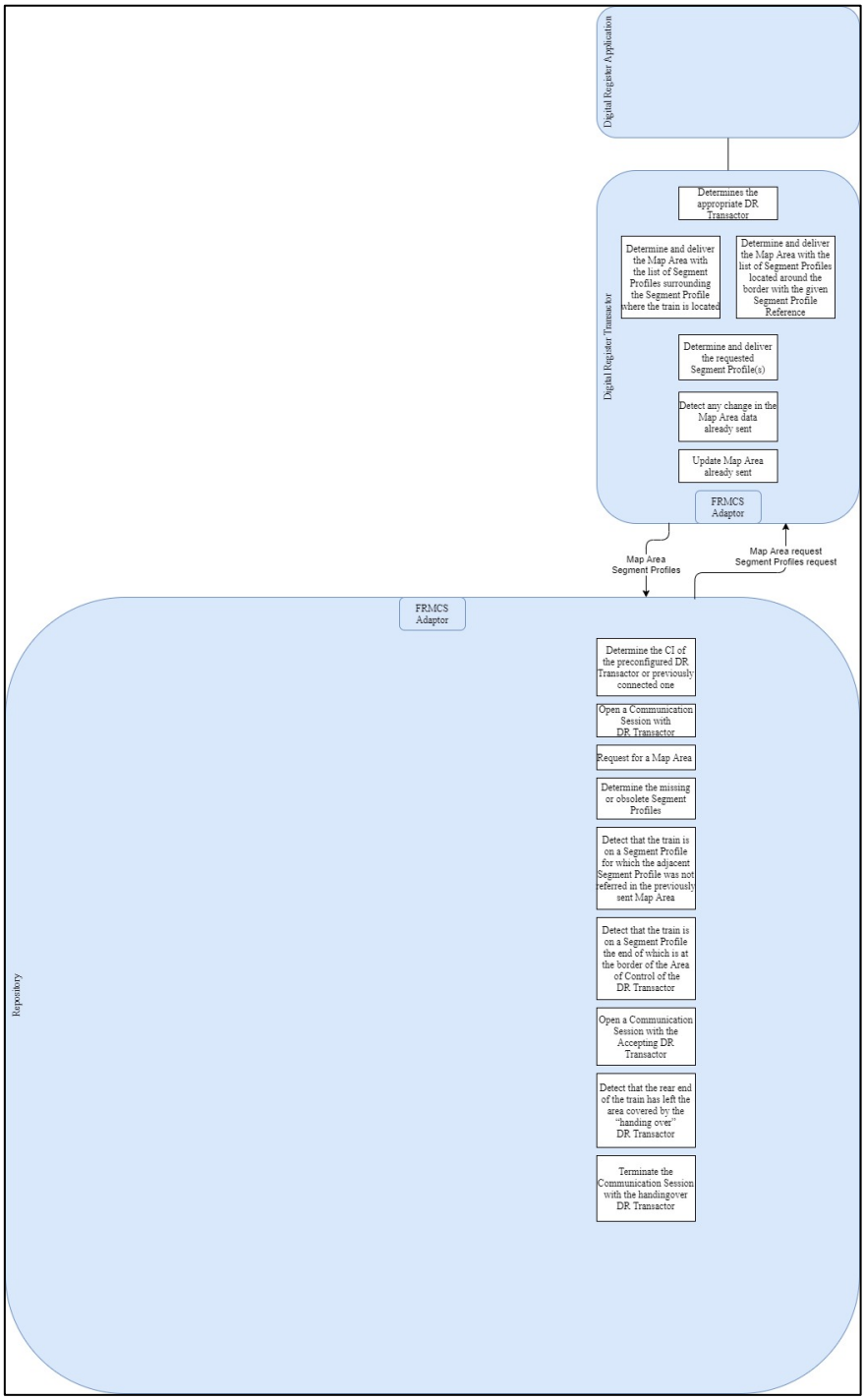

Figure 27: Allocation of functions for Ops1

6.2 Ops 2 or Ops 3

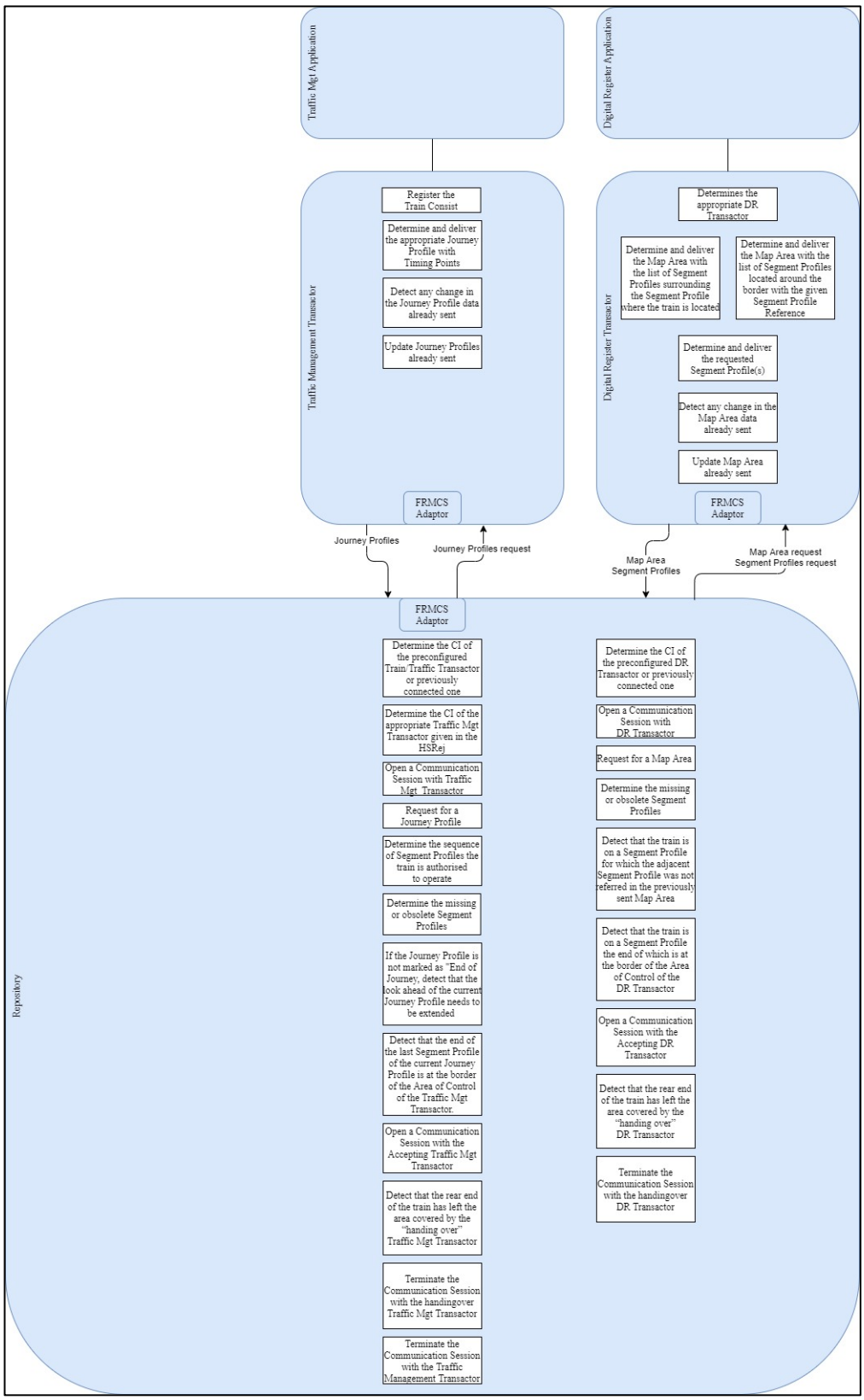

Figure 28: Allocation of functions for Ops 2 and Ops 3

6.3 Ops 4

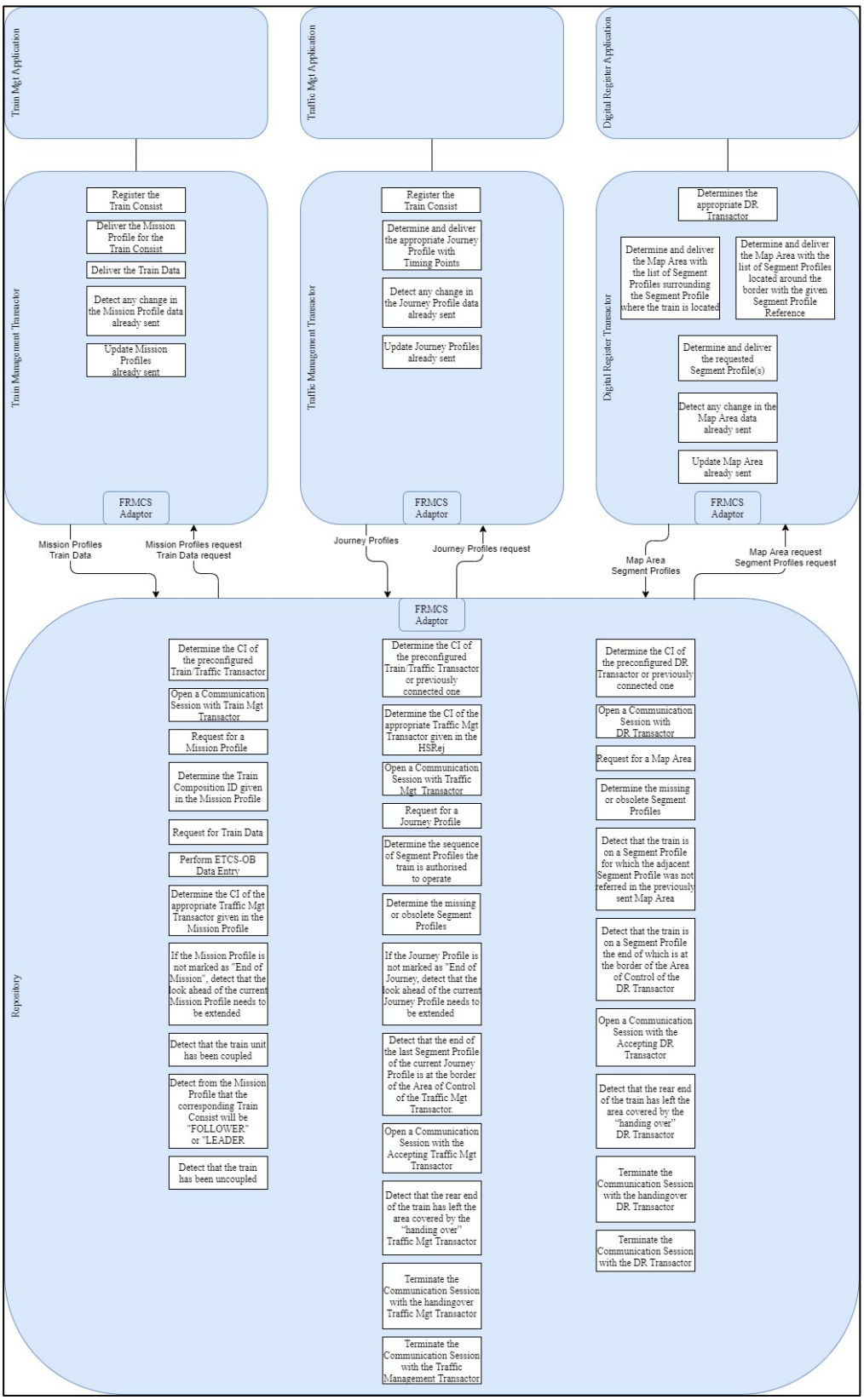

Figure 29: Allocation of functions for Ops 4

7 PHYSICAL ARCHITECTURE CANDIDATES

This chapter defines the possible physical architecture candidates for the logical architecture defined in chapter 6 for all the different operational scenarios.

7.1 Ops 1

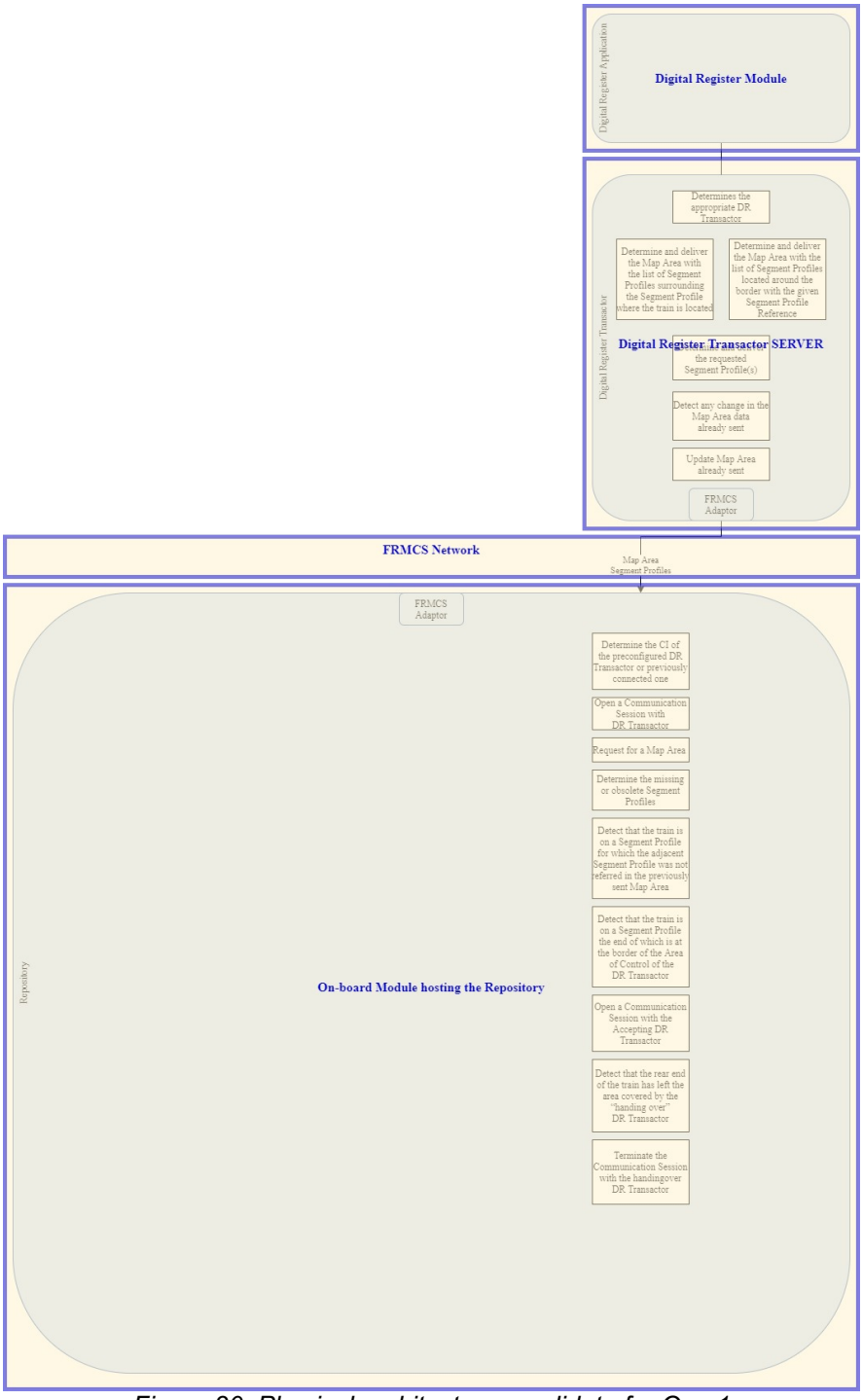

Figure 30: Physical architecture candidate for Ops 1

7.2 Ops 2 (TSI 2023)

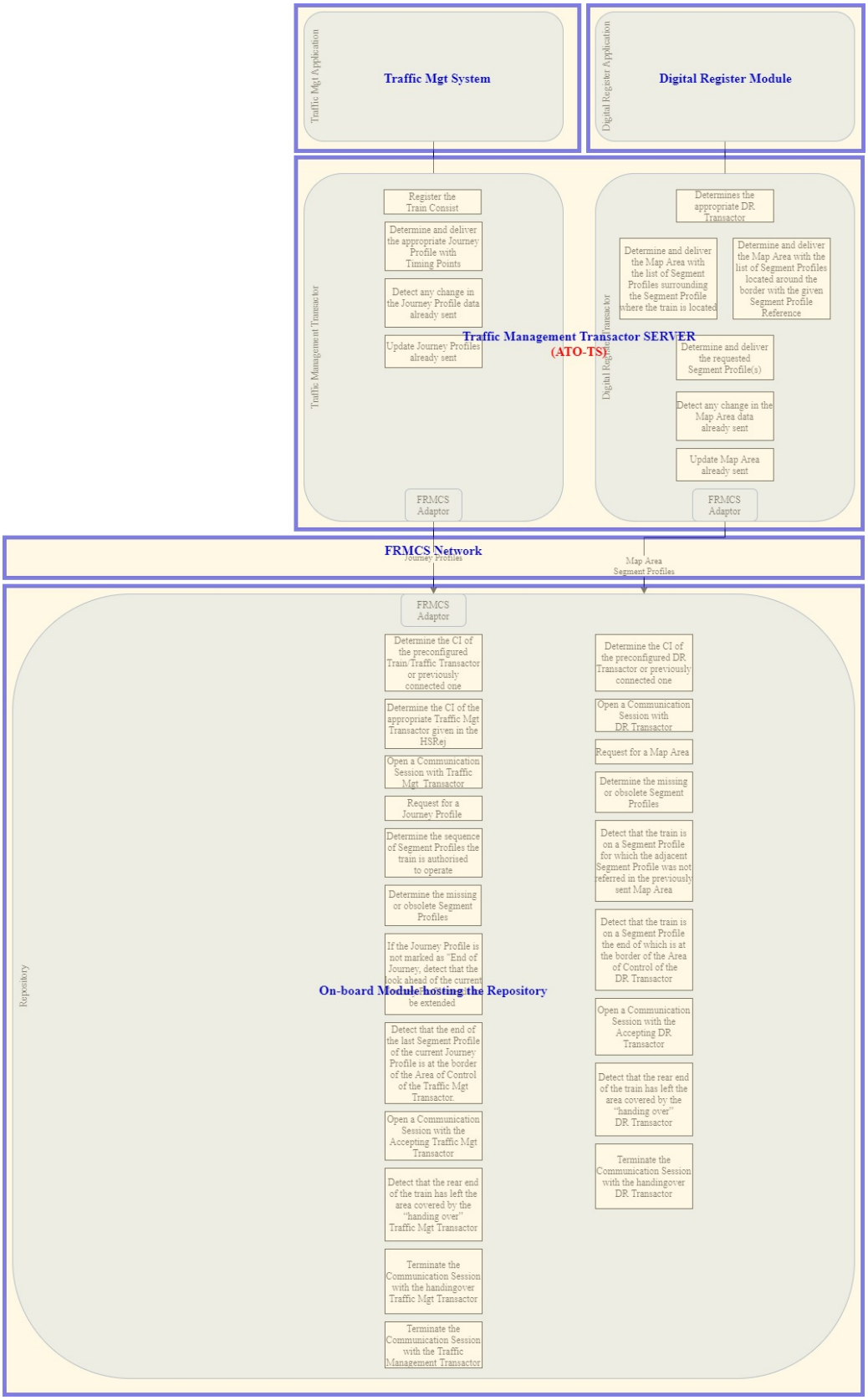

Figure 31 : Physical architecture candidate for Ops 2

7.3 Ops 3

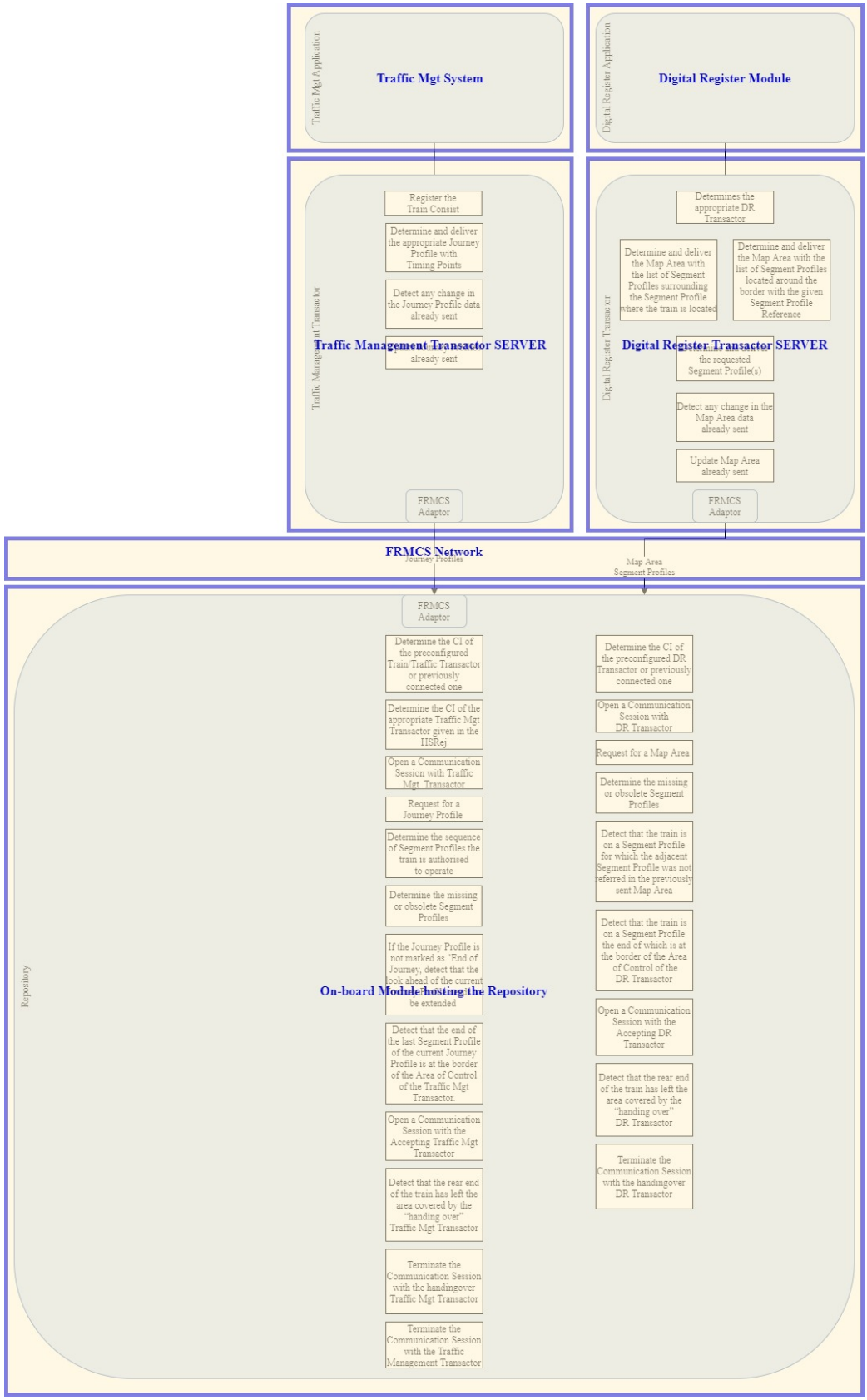

Figure 32: Physical architecture candidate for Ops 3

7.4 Ops 4

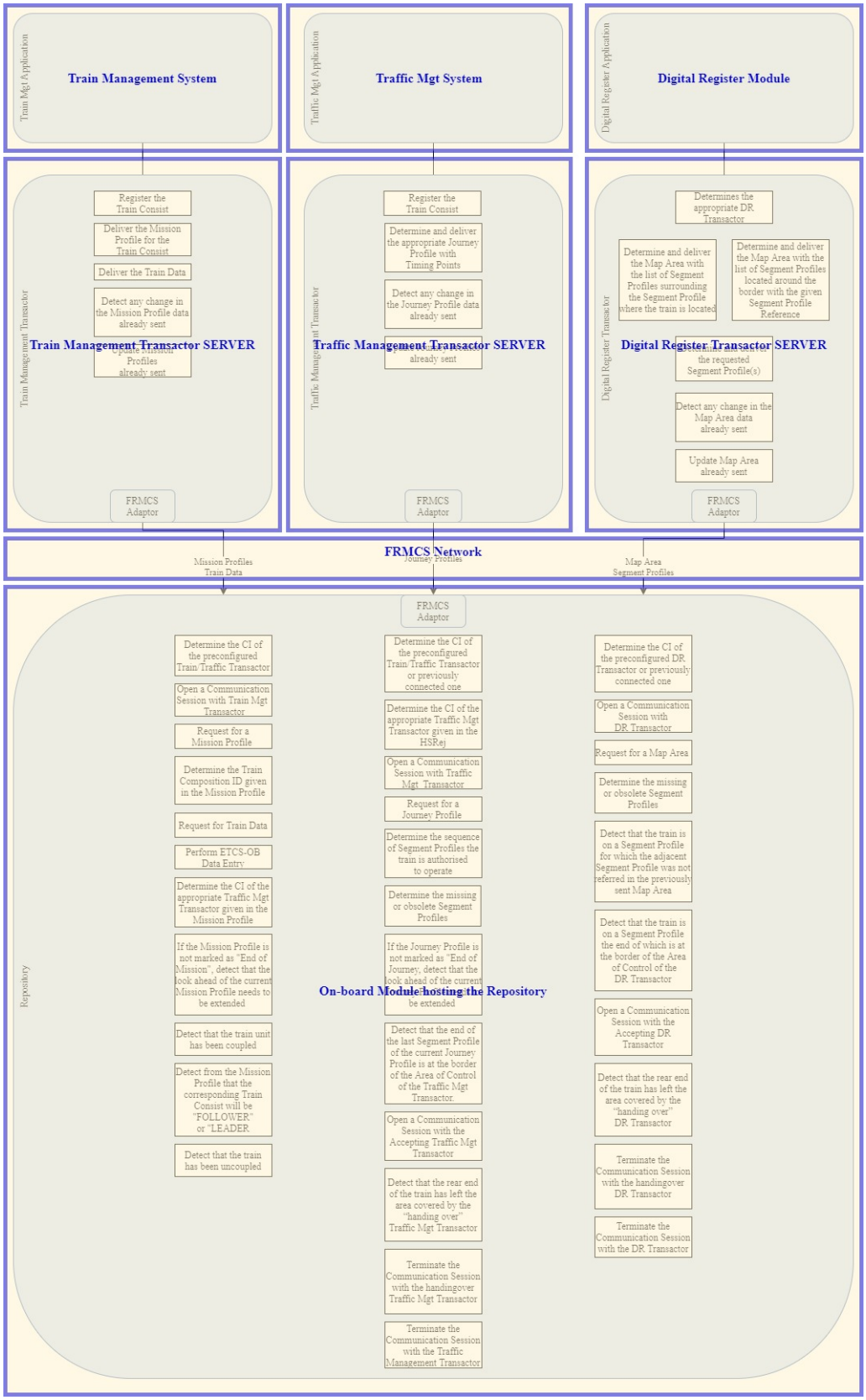

Figure 33: Physical architecture candidate for Ops 4

7.5 Ops 4 supported by IM only

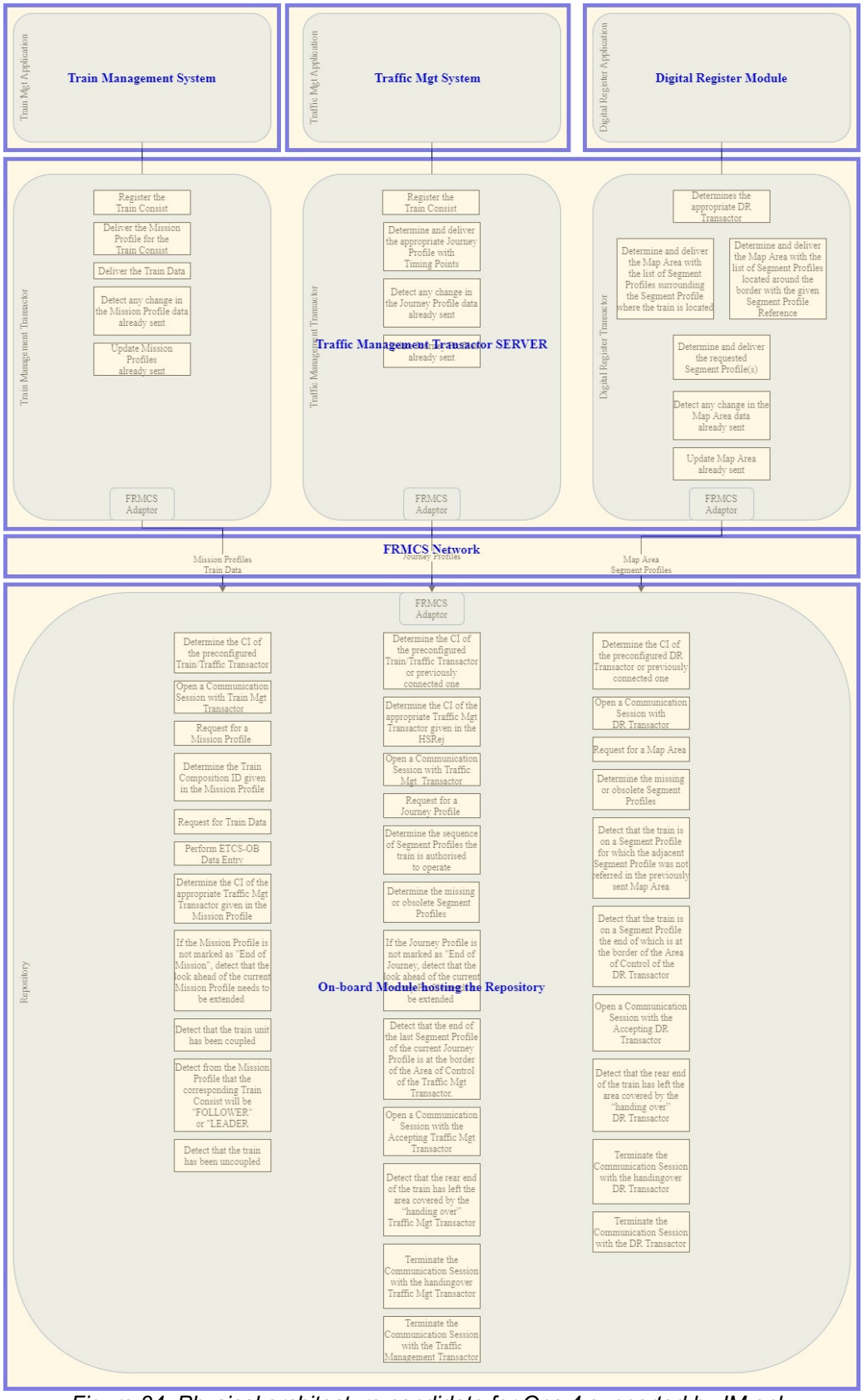

Figure 34: Physical architecture candidate for Ops 4 supported by IM only

8 REFERENCES

[1] D27.1 Initial set of requirements on the Digital Register
[2] 13E154 - ERTMS/ATO Glossary
[3] Subset-125, "ERTMS/ATO System Requirements Specification", Version 1.0.0
[4] Subset-126, "ERTMS/ATO ATO-OB / ATO-TS FFFIS Application Layer", Version 1.0.0