TECHNOLOGIES FOR THE

AUTONOMOUS RAIL OPERATION

Work package 4 –Technologies Supporting Migration to ATO over ETCS

Deliverable 4.2 | Appendix A

Updated GoA3/4 Specification | Lineside Signalling Interpretation

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1 INTRODUCTION

1.1 ACKNOWLEDGEMENTS

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1.3 REFERENCE DOCUMENTS

[1] SUBSET 026, version 3.6.0

[2] X2R4-WP05-D5.1 GoA3/4 Specification, version 0.2.3

[3] Intentionally deleted

[4] SUBSET 125, version 0.2.1

[5] Change Request 1238, upd210223

[6] Europe's Rail Joint Undertaking, Master Plan

[7] EULYNX Domain Knowledge (Eu.Doc.10), version 1.10 (0.A)

[8] EULYNX Interface Specification SCI-LS (Eu.Doc.33), version 3.3 (0.A)

[9] EULYNX Signal Aspect Table, version 2.2 (0.C)

[10] TAURO D4.2 Appendix B

[11] EULYNX Datapreparation model, https://dataprep.eulynx.eu/2022-01/

1.4 ABBREVIATIONS AND ACRONYMS

Abbreviation	Description
AD	Automatic Driving
APM	Automatic Processing Module
ATO	Automatic Train Operation
BG	Balise Group
CCS	Control-Command and Signalling
CEC	Centralized ETCS L1 Controller
DM	Digital Map
EoA / LoA	End of Authority / Limit of Authority
ERTMS	European Rail Traffic Management System
ERJU	Europe’s Rail Joint Undertaking
ETCS	European Train Control System
FFFIS	Form-Fit Function Interface Specification
FIS	Function Interface Specification
FRMCS	Future Railway Mobile Communication System
FS	Full Supervision
GoA	Grade of Automation
GNSS	Global Navigation Satellite System
JP	Journey Profile
IM	Infrastructure Manager
LEU	Lineside Electronic Unit
LRBG	Last Relevant Eurobalise Group
LS	Limited Supervision
LZ	Localization
NTC	National Train Control
OB	Onboard
OCORA	Open CCS Onboard Reference Architecture
OE	Operation Execution
OS	On Sight
PER	Perception
REP	Repository
RTSA	Read Target Signal Aspect (PER function)

RU	Railway Undertaking
SCV	Signalling Converter
SR	Staff Responsible
TAURO	Technologies for the AUtonomous Rail Operation
TMS	Traffic Management System
TP	Train Protection
TRL	Technology Readiness Level
VIP	Virtual Information Point

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2 EXECUTIVE SUMMARY

2.1.1.1.1 In the context of X2RAIL4, standard specification is being completed considering ERTMS/ATO up to GoA4.

2.1.1.1.2 As defined in the Grant Agreement, the task 1, within work package 4 of project TAURO, investigates the possibility to consider the lineside signalling, in order to determine the equivalent Movement Authority to be considered by onboard ATO.

2.1.1.1.3 From a technical point of view, multiple approaches to support ATO operation on non ETCS tracks are feasible. However, due to a couple of restriction jointly identified, the concept is focused on the approach to reuse ERTMS/ATO up to GoA4 specifications as far as possible, i.e. without the need of having NTCs being active or even present on the train.

2.1.1.1.4 As stated in [6] by the European Commission, current systems do not allow GoA4 and as no significant legacy systems implementations exists for automated nor autonomous train operations, research and development activities can deliver EU harmonised solutions for ATO GoA4 over ETCS.

2.1.1.1.5 Therefore, the onboard ATP to be considered in this concept is ERTMS/ETCS.

2.1.1.1.6 This will permit to operate ERTMS/ATO on areas not yet equipped with ERTMS/ETCS, in all GoA levels.

2.1.1.1.7 The perception and interpretation of lineside signalling feeds an onboard ERTMS/ETCS, able to provide the equivalent Movement Authority to ATO, so to run up to GoA4 on areas not yet equipped with ERTMS/ETCS.

2.1.1.1.8 Consequently, the aim of this deliverable is to propose a concept, to enable the use of ERTMS/ATO up to GoA4, on areas not yet equipped with ERTMS/ETCS, on the basis of an ERTMS/ETCS onboard, thanks to the perception and interpretation of lineside signalling.

2.1.1.1.9 When creating the concept, the solution revealed itself to be fully agnostic of the GoA levels, i.e. the system concept could even be reused for manual operation.

2.1.1.1.10 The deliverable uses a semi-formal method, to specify the new elements enabling ERTMS/ATO, on areas not yet equipped with ERTMS/ETCS, with the support of a modelling tool shared between the operator and the suppliers.

2.1.1.1.11 Started from the needs of the Grant Agreement and use cases of the operator, it defines the necessary system functions, and uses a reference architecture compatible with [2], to implement these functions into dedicated logical components. Two components are mainly concerned to current [2] architecture to satisfy the need of operating ERTMS/ATO on areas not yet equipped with ERTMS/ETCS:

- A perception component (PER) that acquires the light signal aspect information,
- A converter component (SCV) that translates light signal aspect information into ERTMS/ETCS compliant information.

2.1.1.1.12 Logical interfaces are described using the data flows exchanged between the functions allocated to the logical components. Several physical implementations are then possible to offer a maximum flexibility for applications.

2.1.1.1.13 The overall concept is a new technological approach to emulate current trackside ERTMS/ETCS Level 1 as defined in [1].

2.1.1.1.14 The technological approach of trackside ERTMS/ETCS Level 1, is to deploy for each light signal, a coder (LEU), and associated Eurobalises, and infill devices if required, to transmit the Movement Authority from trackside to onboard. The ERTMS/ETCS information compliant to the signal aspect is defined during the application engineering phase.

2.1.1.1.15 The light signal aspect is acquired via PER and transmitted to SCV as a standard aspect as defined in [8].

2.1.1.1.16 SCV associates the standard aspect with ERTMS/ETCS data, provided by a Digital Map server.

2.1.1.1.17 National signalling principles are handled the same way as they are in ERTMS/ETCS Level 1 application engineering process and are not addressed in the present document.

2.1.1.1.18 SCV sends the ERTMS/ETCS data to the ERTMS/ETCS onboard, using the localization of the train, the data coming from the Digital Map, and the signal aspect acquired by PER.

2.1.1.1.19 This concept enables an emulation of current trackside ERTMS/ETCS Level 1, and a train-centric approach.

2.1.1.1.20 This concept relies on trains equipped with ERTMS/ETCS onboard and is a migration solution supporting ERTMS/ATO and future radio-based ERTMS/ETCS trackside.

2.1.1.1.21 This concept will not achieve the headway performance of radio-based ERTMS/ETCS Levels.

2.1.1.1.22 In this concept, Automatic Train Protection is ensured on these areas, by ERTMS/ETCS onboard in conjunction with SCV and PER.

2.1.1.1.23 Areas equipped with class B systems without light signals (CAB-SIGNAL ensured by the class B) are out of scope.

2.1.1.1.24 As this concept proposes a new mean of transmission towards ERTMS/ETCS onboard, it does not require modifications on SUBSET 125, SUBSET 126 and SUBSET 130 specifications. Standard solution ERTMS/ATO is reused as is. However, it exports new functions and constraints to existing modules in [2]. These exported constraints are defined in 11.

2.1.1.1.25 The Technology Readiness Level that will be achieved by TAURO work package 4, task 1, is TRL 2: technology concept and/or application formulated.

2.1.1.1.26 Projects performed outside TAURO 4.1 (*Train de Fret Autonome* in France, *ATO over ATB* in the Netherlands) have brought the use of lineside signalling perception to enable ERTMS/ATO on areas not yet equipped with ERTMS/ETCS, to TRL 6: large scale prototype tested in intended environment.

2.1.1.1.27 This concept must be further studied to become a specification, especially operational rules and hazard analysis.

3 INTRODUCTION

3.1 PROBLEM STATEMENT

3.1.1 ERTMS/ATO operational in GoA2 context

3.1.1.1.1 As defined in [4] §9.1.1, ERTMS/ATO onboard shall be ready for ATO operation when the ETCS-OB applicable conditions for ATO operational are fulfilled.

3.1.1.1.2 As defined in [4] §9.1.1.2, the ETCS-OB applicable conditions for ATO Operational are:

- The ETCS-OB is in AD Mode or FS Mode and conditions for displaying "ENTERING FS" no longer exists.
- The ETCS-OB is not commanding the Emergency Brake or Full Service Brake.

3.1.1.1.3 As defined in [5], Automatic Driving mode is used in levels 1, 2, 3.

3.1.1.1.4 Automatic Driving is impossible in levels 0, NTC.

3.1.1.1.5 Automatic Driving mode availability according to [5] is synthesised in the table below:

Trackside ERTMS/ETCS level	Onboard ERTMS/ETCS level	Onboard ERTMS/ETCS mode	AD mode
Level 0	Level 0	UN	Impossible
Level NTC	Level NTC	SN	Impossible
Level 1	Level 1	FS	Possible
Level 2/3	Level 2/3	FS	Possible

Table 1: AD mode availability

3.1.2 ERTMS/ATO operational in GoA34 context

3.1.2.1.1 In the GoA34 context, assumptions are made regarding the AD Mode.

3.1.2.1.2 As defined in [2], Train Control is the component that provides the Movement Authorities to the trains.

3.1.2.1.3 As defined in [2], Train Control provides a Movement Authority (MA) to Train Protection in AD, LS, FS and OS modes.

3.1.2.1.4 As defined in [2], automatic operation is only possible in AD mode in which there is no warning curve (W) supervision. This mode can be activated from FS mode when all ATO operational conditions are satisfied. In other modes (LS, FS, OS), the driver will drive according to the warning curve (W).

3.1.2.1.5 As defined in [2], the management of AD mode must be reviewed in the GoA34 context. It is reserved for FS in GoA2, but it must be adapted to OS mode in GoA3/4. Other ETCS modes are currently not considered for running automatically in GoA3/4.

3.1.3 Problem to be solved by this concept

3.1.3.1.1 Both in GoA2 and GoA34 contexts, the absence of Train Control leads Train Protection to switch either in level 0 or level NTC.

3.1.3.1.2 No AD mode is foreseen in [2] for Train Protection in level 0 and level NTC.

3.1.3.1.3 Therefore, the problem to be solved is to make available the AD mode, up to GoA4 as defined in [2], even in the absence of Train Control.

3.1.4 Constraints

3.1.4.1.1 Shift2Rail TAURO project, work package 4, is focusing on *Technologies supporting migration to ERTMS/ATO*. Task 4.1 has been settled to define a concept to enable the use of ERTMS/ATO, up to GoA4, on areas not yet equipped with ERTMS/ETCS trackside, via the perception and interpretation of lineside signalling.

3.1.4.1.2 This perception and interpretation of lineside signalling feeds an onboard ATP, able to provide the equivalent Movement Authority to ATO, so to run up to GoA4 on areas not yet equipped with ERTMS/ETCS.

3.1.4.1.3 As stated in [6] by the European Commission, current systems do not allow GoA4 and as no significant legacy systems implementations exists for automated nor autonomous train operations, research and development activities can deliver EU harmonised solutions for ATO GoA4 over ETCS.

3.1.4.1.4 Therefore, the onboard ATP to be considered in this concept is ERTMS/ETCS.

3.1.5 Purpose

3.1.5.1.1 Consequently, the aim of this document is to propose a concept, to enable the use of ERTMS/ATO up to GoA4, on areas not yet equipped with ERTMS/ETCS, on the basis of an ERTMS/ETCS onboard delivering AD mode, thanks to the perception and interpretation of lineside signalling.

3.2 Scope and Assumptions

3.2.1.1.1 The concept relies on ERTMS/ATO as defined in [4], and on the use of an ERTMS/ETCS onboard unit.

3.2.1.1.2 The concept defined in this document is to be used on areas equipped with light signals as defined in 7.2.

4 OPERATIONAL ANALYSIS

4.1 NEEDS AND REQUIREMENTS

4.1.1.1.1 Needs extracted from the Grant Agreement are the following:

- The concept shall enable ERTMS/ATO on areas not yet equipped with ERTMS/ETCS,
- The concept shall consider areas equipped with class B systems,
- The concept shall consider garage yards.
- The concept shall consider transitions from an ERTMS/ETCS fitted area to a class B fitted area and vice-versa.

NOTE: ERTMS/ETCS fitted area means an area equipped with trackside ERTMS/ETCS Level 1 or Level 2/3.

- The concept shall consider transitions from an ERTMS/ETCS fitted area to a shunting area and vice-versa.

4.1.1.1.2 According to [1], areas equipped with class B systems are ERTMS/ETCS trackside Level NTC areas.

4.1.1.1.3 In this concept, ERTMS/ETCS Level NTC areas, equipped with light signals as defined in 7.2 are considered.

4.1.1.1.3.1 In this concept, ERTMS/ETCS Level NTC areas not equipped with light signals are out of scope.

4.1.1.1.4 As garage yards can be unfitted (not equipped with an ATP system), they can be considered as ERTMS/ETCS trackside Level 0 areas.

4.1.1.1.5 In this concept, ERTMS/ETCS Level 0 areas equipped with light signals as defined in 7.2 are considered.

4.1.1.1.5.1 In this concept, ERTMS/ETCS Level 0 areas not equipped with light signals are out of scope.

4.1.1.1.6 Needs expressed by the operator in Task 1:

- The concept shall reuse ERTMS/ATO solution as defined in [4].
- The concept shall minimize the impact on existing infrastructure.
- The concept shall ease the migration of the infrastructure towards ERTMS/ETCS, with the involvement of the infrastructure manager.
- The concept shall take advantage of new technologies available:
  - Onboard navigation systems,
  - Onboard perception systems.

4.2 SYSTEM CAPABILITIES

4.2.1.1.1 The needs are translated into system capabilities.

4.2.1.1.2 The system capabilities in the scope are:

- Enable ERTMS/ATO up to GoA4 in Level NTC area equipped with light signals,
- Enable ERTMS/ATO up to GoA4 in Level 0 area equipped with light signals,

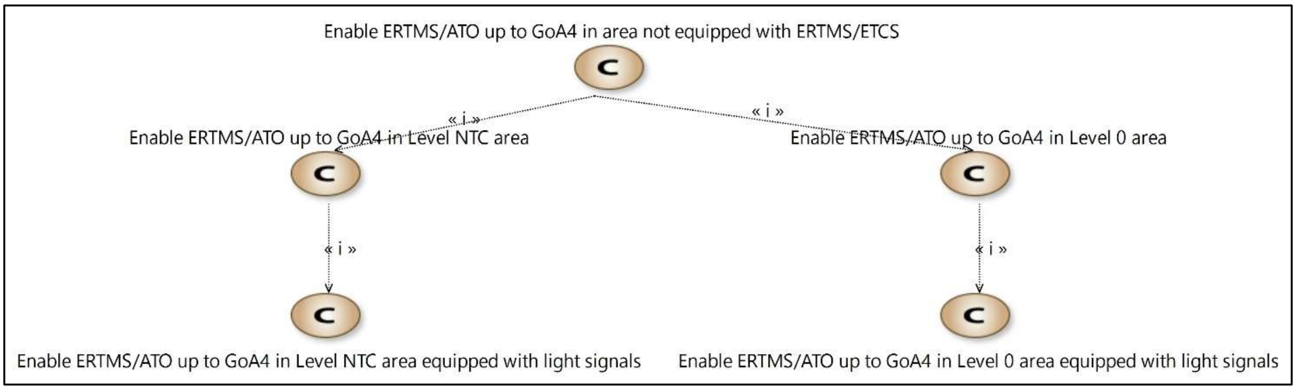

Figure 1: System capabilities

5 SYSTEM ANALYSIS

5.1 INTRODUCTION

5.1.1.1.1 In this paragraph, the document will point out the construction of the system delivered by the concept. Starting from a black-box analysis, only focusing on inputs and outputs of the system, the analysis will continue with the identification of functions and their allocation to logical components.

5.1.1.1.2 This system shall cover the two capabilities mentioned above:

- Enable ERTMS/ATO up to GoA4 in Level NTC area equipped with light signals,
- Enable ERTMS/ATO up to GoA4 in Level 0 area equipped with light signals,

5.1.1.1.3 To be compatible up to GoA4, the system will be constructed based on the assumptions made in [2].

5.2 BLACK BOX ANALYSIS

5.2.1.1.1 The system function is to *Provide all track data, which are required for a complete supervision of the train, and that are compliant to the displayed lineside signal aspect.*

5.2.1.1.2 This function satisfies the capabilities defined in 4.2.

5.2.1.1.3 As defined in [1], this function enables the ERTMS/ETCS onboard to get into Full Supervision mode.

5.2.1.1.4 The system actors are:

- Light Signal,
- Train Protection.

5.2.1.1.5 ATO-AV is an actor of the super-system represented for understanding purpose, as the final goal of this concept is to enable ERTMS/ATO on lines not yet equipped with ERTMS/ETCS.

5.2.1.1.6 At this stage, the system shall transmit ERTMS/ETCS data, based on the aspect displayed by the light signal.

5.2.1.1.7 The system in black box is illustrated in the figure below:

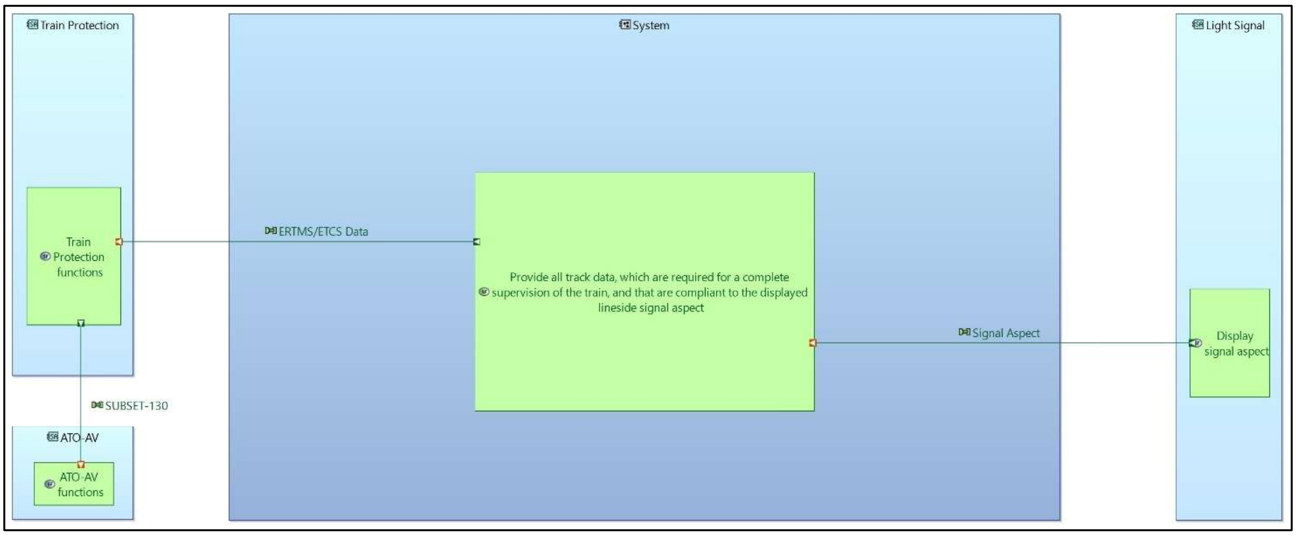

Figure 2: Black-box analysis

5.3 White box analysis

5.3.1 General

5.3.1.1.1 In the white box analysis, the system function *Provide all track data, which are required for a complete supervision of the train, and that are compliant to the displayed lineside signal aspect* is divided into several functions.

5.3.1.1.2 To remain consistent with [2], some system assumptions are made.

5.3.1.1.3 Assumption 1: A Journey Profile is provided by the function *Determine/verify and transmit JP data*, allocated to the actor Operational Execution.

5.3.1.1.4 Assumption 2: The Journey Profile is the key to contacting the Digital Map, and to retrieve all necessary infrastructure data. Infrastructure data are provided by the function *Provide infrastructure data*, allocated to the actor Digital Map.

5.3.1.1.5 To remain consistent with [2], train localization is ensured by the system, via a dedicated function *Localize vehicle.*

5.3.1.1.6 The system functions are:

- Acquire JP (function defined in [2]),
- Acquire Segment Profile information (function defined in [2]),
- Localize vehicle (function defined in [2]),
- Acquire the expected signal aspects in the route of the JP,
- Read the target signal aspect,
- Select and send ERTMS/ETCS Data.

5.3.1.1.7 At this stage, the system shall transmit ERTMS/ETCS data, based on the localization of the train on the track, Segment Profile static information from the Digital Map, and the signal aspect provided by the light signal.

5.3.1.1.8 Note 1: light signal aspects being the visual representation of the interlocking state, it is possible to retrieve the expected signal aspect at trackside level (interlocking and/or traffic management system).

5.3.1.1.9 Note 2: this possibility is provided by the concept, by the use of the function *Determine and transmit expected signal aspect,* allocated to Operational Execution.

5.3.1.1.10 Note 3: the use of an expected signal aspect, provided by Operational Execution, is optional.

5.3.1.1.11 Note 4: the function *Determine and transmit expected signal aspects*, is an exported constraint to the logical element Operational Execution, dealt within X2RAIL4.

5.3.1.1.12 The system in white-box is illustrated in the figure below:

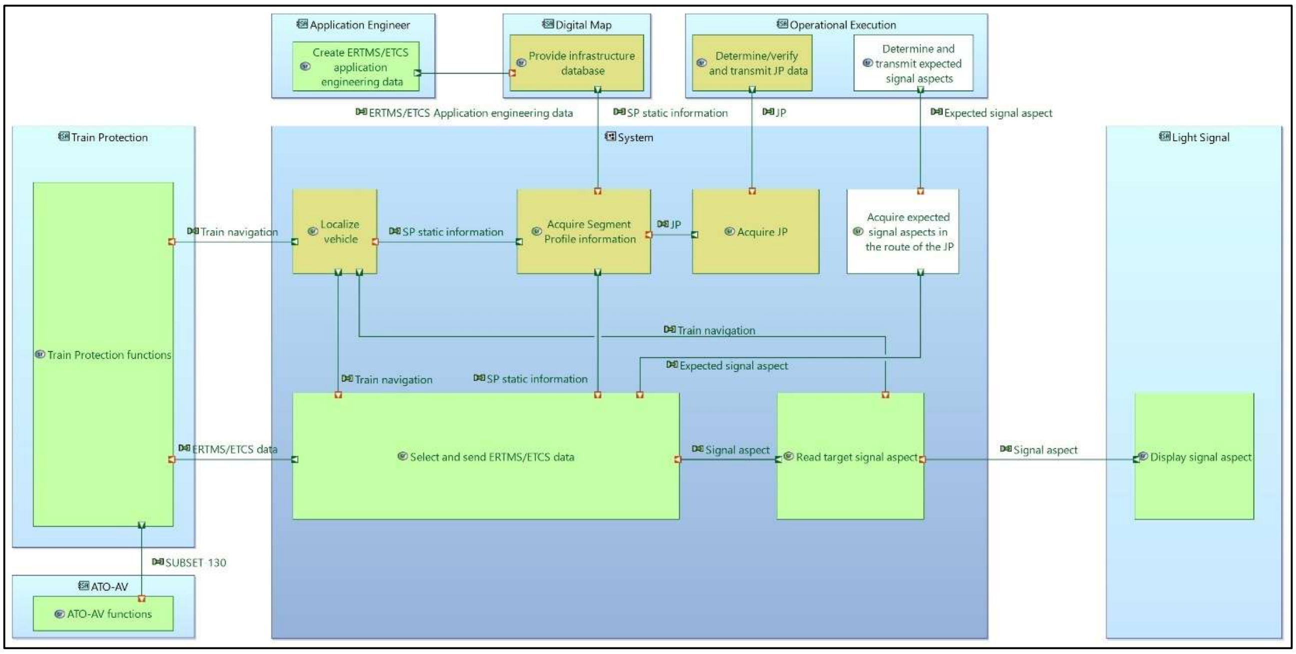

Figure 3: White-box analysis

NOTE : Functions in orange are in the scope of study of X2RAIL4 project. More details can be found in [2]. Functions in white are exported functions to X2RAIL4.

5.3.2 Application engineering process

5.3.2.1.1 As for current ERTMS/ETCS Level 1 trackside deployment, ERTMS/ETCS application data are required to determine what ERTMS/ETCS information are applicable to an aspect of a given light signal.

5.3.2.1.2 This application engineering process is fulfilled by the function *Create ERTMS/ETCS application engineering data*.

5.3.2.1.3 In this concept, this function is allocated to an actor of the super-system: the Application Engineer.

5.3.2.1.4 The output of the application engineering process feeds the function *Provide infrastructure database* of the actor Digital Map.

5.3.2.1.5 Based on this application engineering data coming from the Digital Map, the system selects the relevant ERTMS/ETCS data compliant to the signal aspect.

NOTE: It was requested by the operator to leave the possibility to allocate this function *Create ERTMS/ETCS application engineering data* to the system, where ERTMS/ETCS application engineering data could be generated onboard and on-the-fly. As such an allocation opens questions regarding the interoperability, the application engineering standardization (partially dealt in [11]), and the certification, this approach is not studied in the concept.

5.3.3 Dynamic Behavior

5.3.3.1.1 The functional scenario of the system function Provide all track data, which are required for a complete supervision of the train, and that are compliant to the displayed lineside signal aspect is displayed in the figure below:

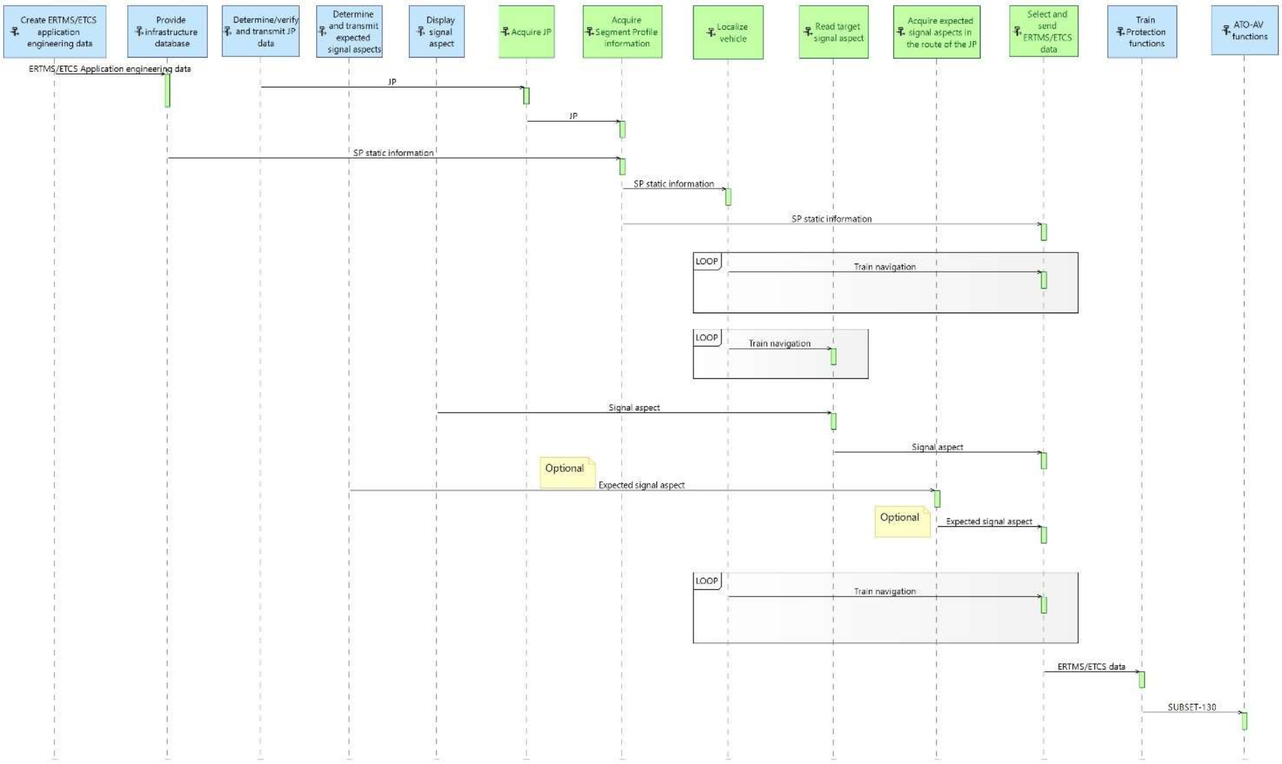

Figure 4: Functional Scenario, system analysis

6 LOGICAL ANALYSIS

6.1 INTRODUCTION

6.1.1.1.1 In the logical analysis of the system, functions defined in 5.3.1.1.6 are refined and allocated to logical components.

6.1.1.1.2 The Figure 5: Logical system shows the logical architecture of the complete system required to fulfil the use of ERTMS/ATO on Level 0 and Level NTC areas that are equipped with light signals.

6.1.1.1.3 The required onboard logical components are within the “System” component.

6.1.1.1.4 Logical components in yellow are in the scope of study of TAURO 4.1 work package.

6.1.1.1.5 Logical components in cyan are required by the concept but out of the scope of study as they are already addressed in X2RAIL4 project. TAURO 4.1 exports functions and constraints to these components.

6.1.1.1.6 Logical components in blue are system actors to which TAURO 4.1 exports functions and constraints.

6.1.1.1.7 The system architecture is made of logical components with logical interfaces (FIS level).

6.1.1.1.8 The communication channels between onboard and trackside components are C34 for infrastructure data and C14 for operational data. These communication channels are described in [2].

6.1.1.1.9 The logical components identified in the logical architecture permit interchangeability and interoperability. They must be allocated to physical components in a physical architecture defined at FFFIS level.

6.1.1.1.10 As the task 4.1 is to define a concept, physical architecture and FFFIS interfaces are out of scope and must be defined by further projects.

6.1.1.1.11 The analysis will focus on PER and SCV components, their interfaces and exported constraints towards surrounding components described in [2] (REP, DM, OE, ATO-AV), in other projects and/or initiatives (Localization), and ERTMS/ETCS (Train Protection).

- DM is the Digital Map of the Infrastructure Manager, located trackside,
- OE manages the interface with new or legacy Traffic Management Systems of the Infrastructure Manager, located trackside,
- REP manages the interoperable communication with trackside components and stores relevant information,
- Localization provides the location and heading of the train to consumers in 1D (ERTMS/ETCS reference and Segment Profile reference) and 3D (WGS84 reference),
- SCV, based on localization and REP information, triggers the perception (PER) and REP, asking for the aspect of the next target light signal. It transmits the ERTMS/ETCS packets associated with the signal aspect provided by PER, and REP optionally, when the train passes the light signal,

- PER, when asked by SCV to do so, extracts the target light signal aspect from the physical environment, and provides it to SCV,
- Train Protection supervises the train via information provided by SCV, and provides ATO-AV with SUBSET-130,
- ATO-AV performs traction and braking according to [2] and [4].

6.1.1.1.12 The concept principles, terms, definitions, and data model are described in 7.

6.1.1.1.13 PER and SCV logical components are described in 8 and 9 with their allocated functions and requirements.

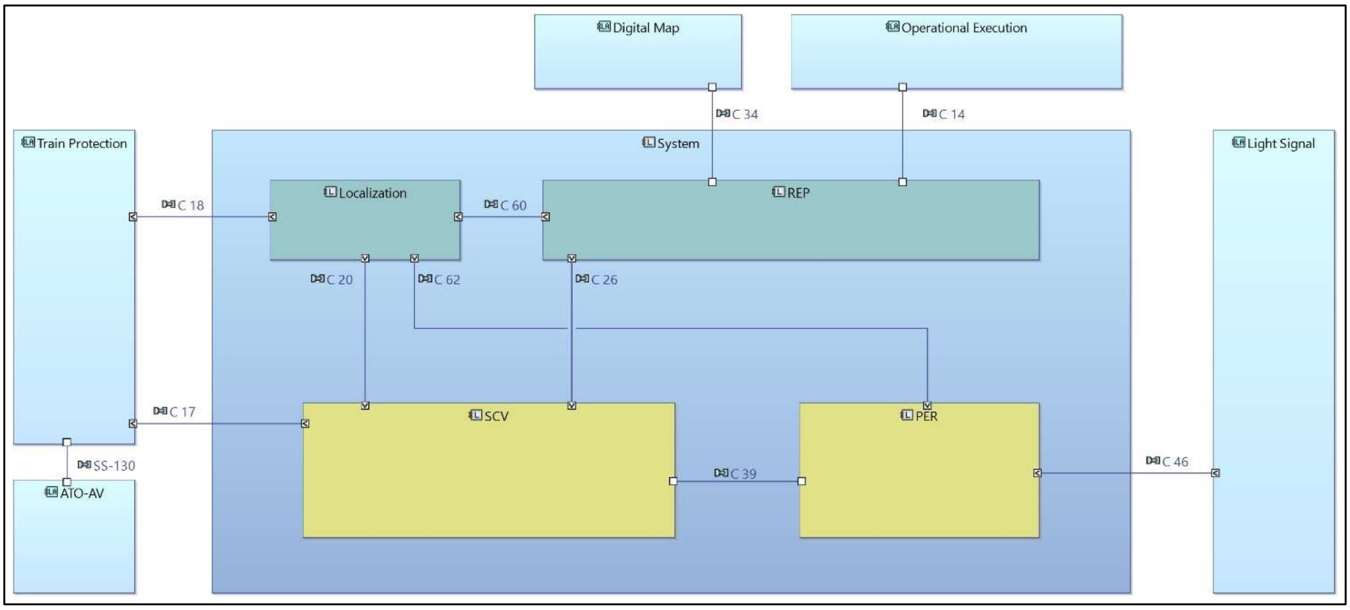

Figure 5: Logical system

6.2 Function allocation to logical components

6.2.1 In the scope of study of TAURO 4.1

Function	Sub-function	Allocation
Read target signal aspect	None	PER
Select and send ERTMS/ETCS data	Acquire target signal aspect	SCV
	Retrieve localization and database	SCV
	Provide ERTMS/ETCS data	SCV

Table 2: Functions allocation

6.2.2 Out of the scope of study of TAURO 4.1

Function	Allocation
Provide infrastructure database	Digital Map

Display signal aspect	Light Signal
Localize vehicle	Localization
Determine/verify and transmit JP	Operational Execution
Determine and transmit expected signal aspects	Operational Execution
Acquire JP	REP
Acquire Segment Profile information	REP
Acquire the expected signal aspect in the route of the JP	REP
Train protection functions	Train Protection

Table 3: Functions allocation

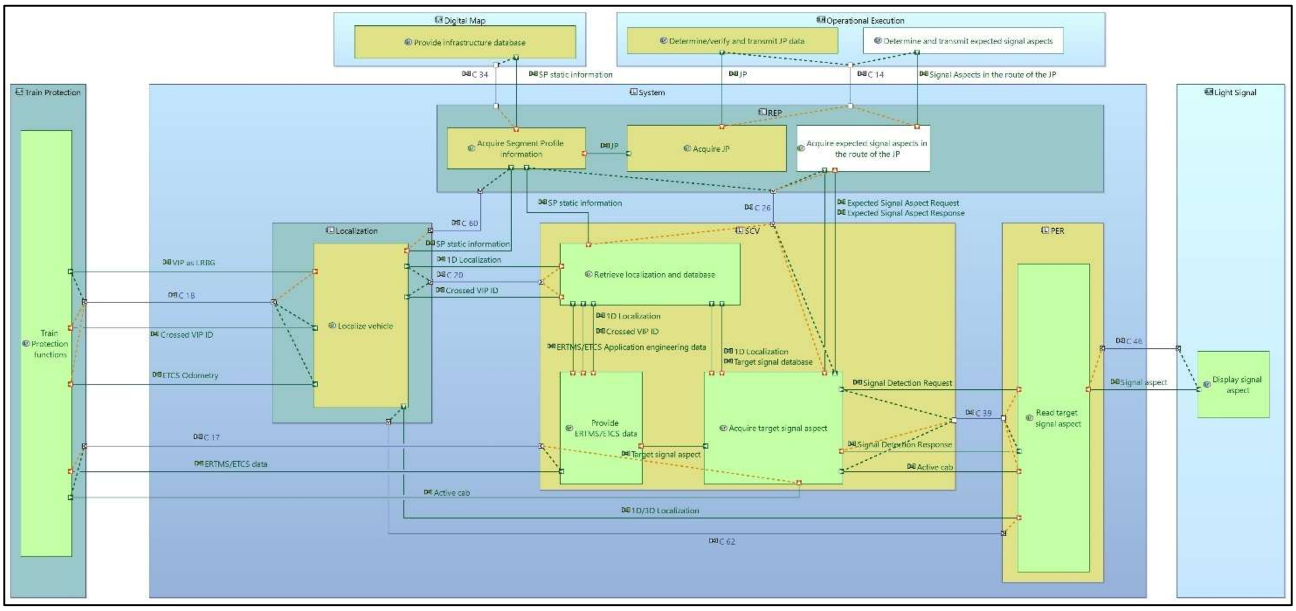

Figure 6: Logical system with allocated functions

6.3 Dynamic Behaviour

6.3.1.1.1 The dynamic behaviour of the system is presented in the exchange scenario below:

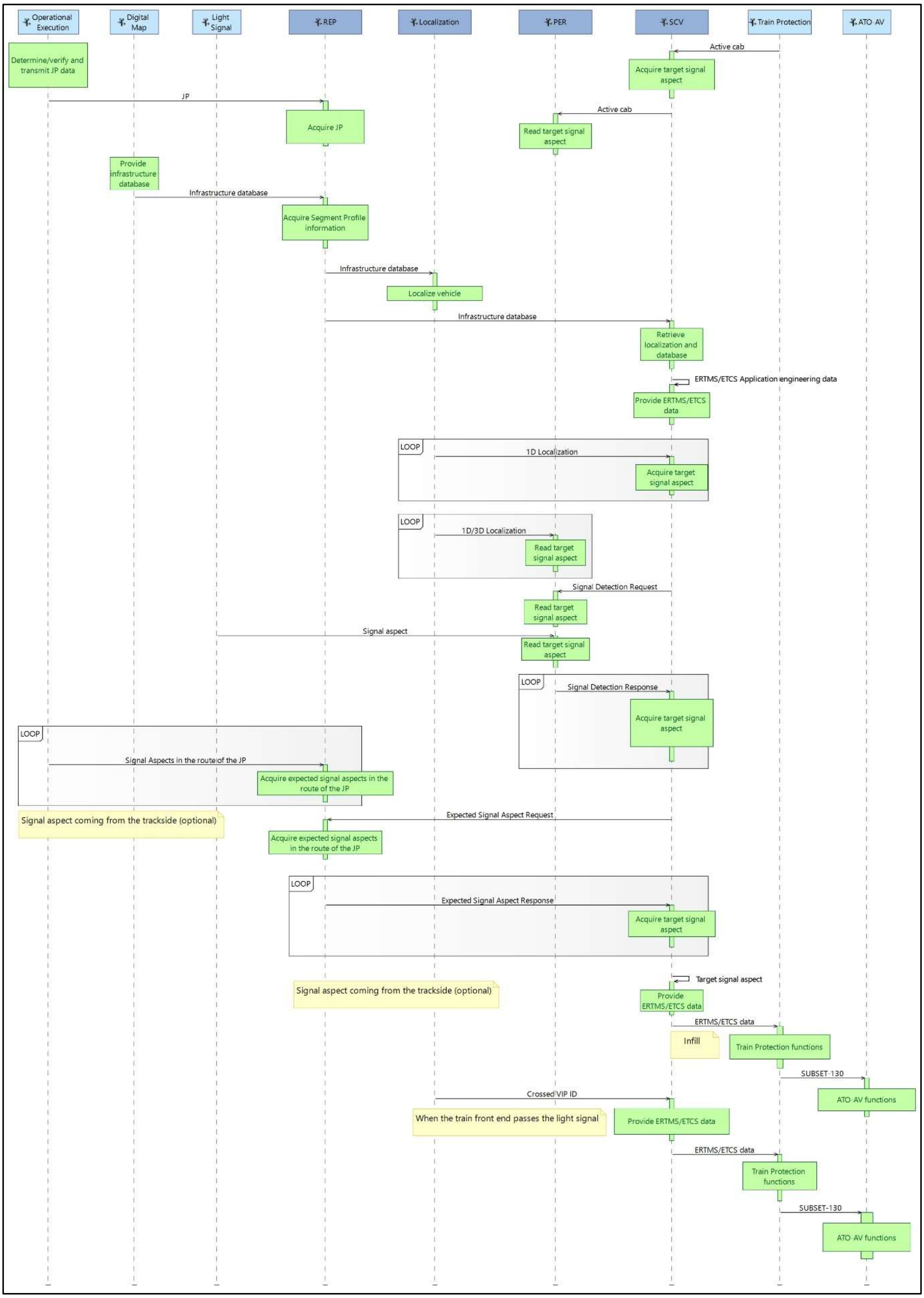

Figure 7: Exchange Scenario, logical system

7 CONCEPT PRINCIPLES

7.1 GENERAL PRINCIPLES

7.1.1 Operational Execution and JP

7.1.1.1.1 Operational Execution is the module connected to new or legacy Traffic Management Systems, that provides the Journey Profile to the onboard component REP.

7.1.1.1.2 The Journey Profiles provide the theoretical route in the infrastructure and the contact information to a Digital Map server.

7.1.2 Digital Map and data model

7.1.2.1 Introduction

7.1.2.1.1 As defined in [2], Digital Map shares infrastructure data with relevant applications.

7.1.2.1.2 Data is stored in the Digital Map in a layered architecture, as defined in Figure 8:

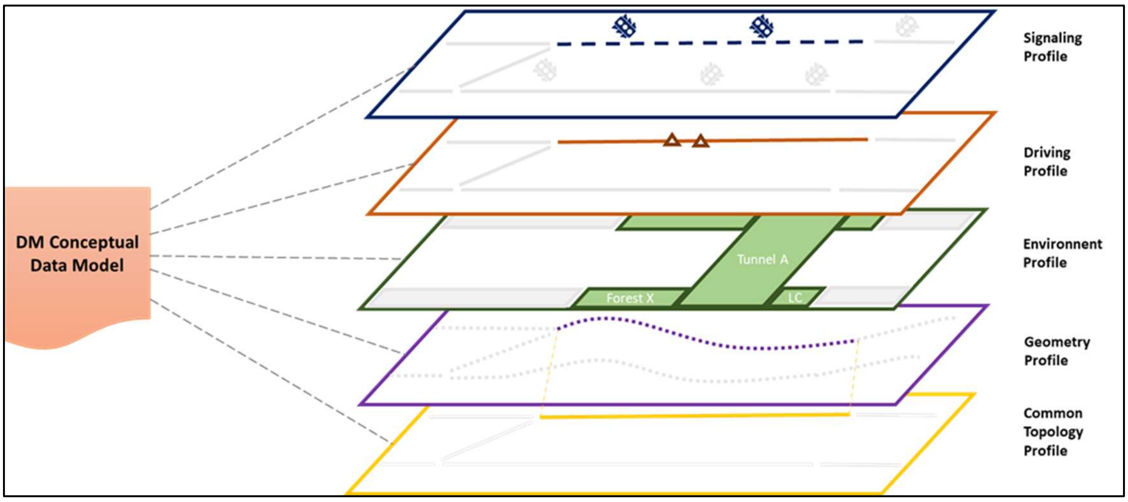

Figure 8: DM layered architecture

7.1.2.1.3 The concept uses data from the geometry profile and the signalling profile.

7.1.2.2 Geometry Profile

7.1.2.2.1 As defined in [10], this layer describes the track layout geometry. Each track segment is represented by straight lines (polylines) with track vertices sampling used for navigation and positioning. These points are generally described by 3D geometric coordinates.

7.1.2.3 Signalling profile

7.1.2.3.1 As defined in [10], this layer describes the line side signalling components (fixed and mobile signalling). Such a layer is mainly related to the function of detection and interpretation of lineside signalling information. It could contain also virtual signalling information.

7.1.3 REP

7.1.3.1.1 As defined in [2], REP logical component filters all data received from DM (segment profile static data), OE (journey profile data, segment profile dynamic data), MD (mission profile data) and TD (train data set) according to the needs of the on-board logical components and forwards them through the relevant interfaces.

7.1.3.1.2 The communication principles between REP and trackside logical components are detailed in [2] chapter 15. From a data point of view, REP will upload segment profile static data from DM associated to the journey profiles received from IM.

7.1.3.1.3 As defined in [2], REP applies for GoA2, GoA3 and GoA4.

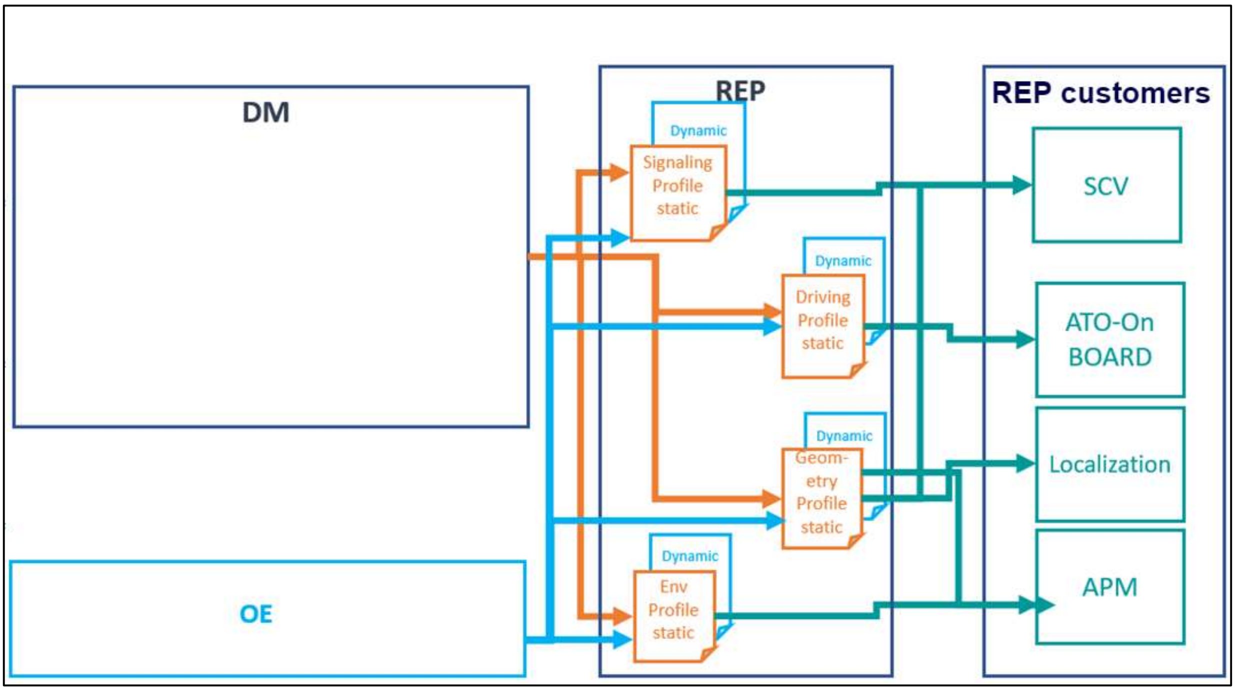

Figure 9: Data flow between the logical building blocks

7.1.4 Exchange scenario

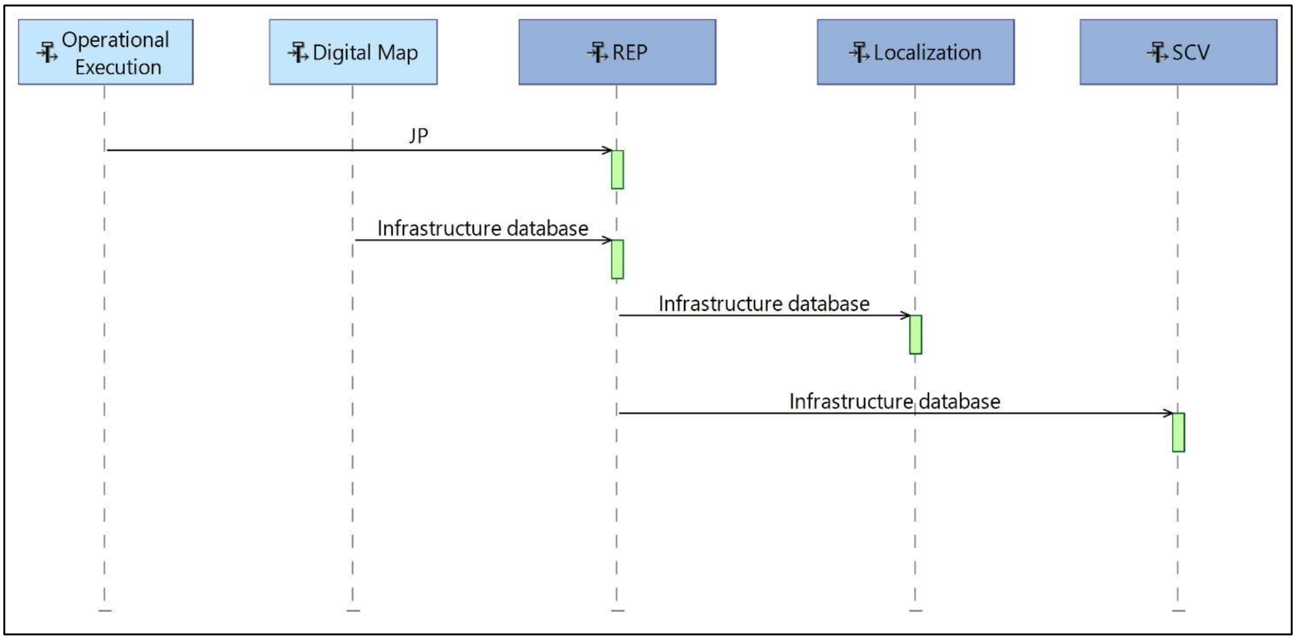

Figure 10: Exchange scenario, data retrieval from OE and DM

7.2 LIGHT SIGNAL

7.2.1.1.1 As defined in [11], a light signal is a specialization of an active signal, providing its aspect via lamps.

7.2.1.1.2 As defined in [11], an active signal is a signal with an actively controlled aspect.

7.2.1.1.3 As defined in [11], an active signal is a specialization of a physical signal.

7.2.1.1.4 As defined in [11], a physical signal is a signal with a physical line-side appearance.

7.2.1.1.5 As defined in [11], a physical signal is a specialization of a signal.

7.2.1.1.6 As defined in [11], a signal is a line-side element that sends a message to the driver. The signal consists of several signal frames, each of which carries part of the message to the driver.

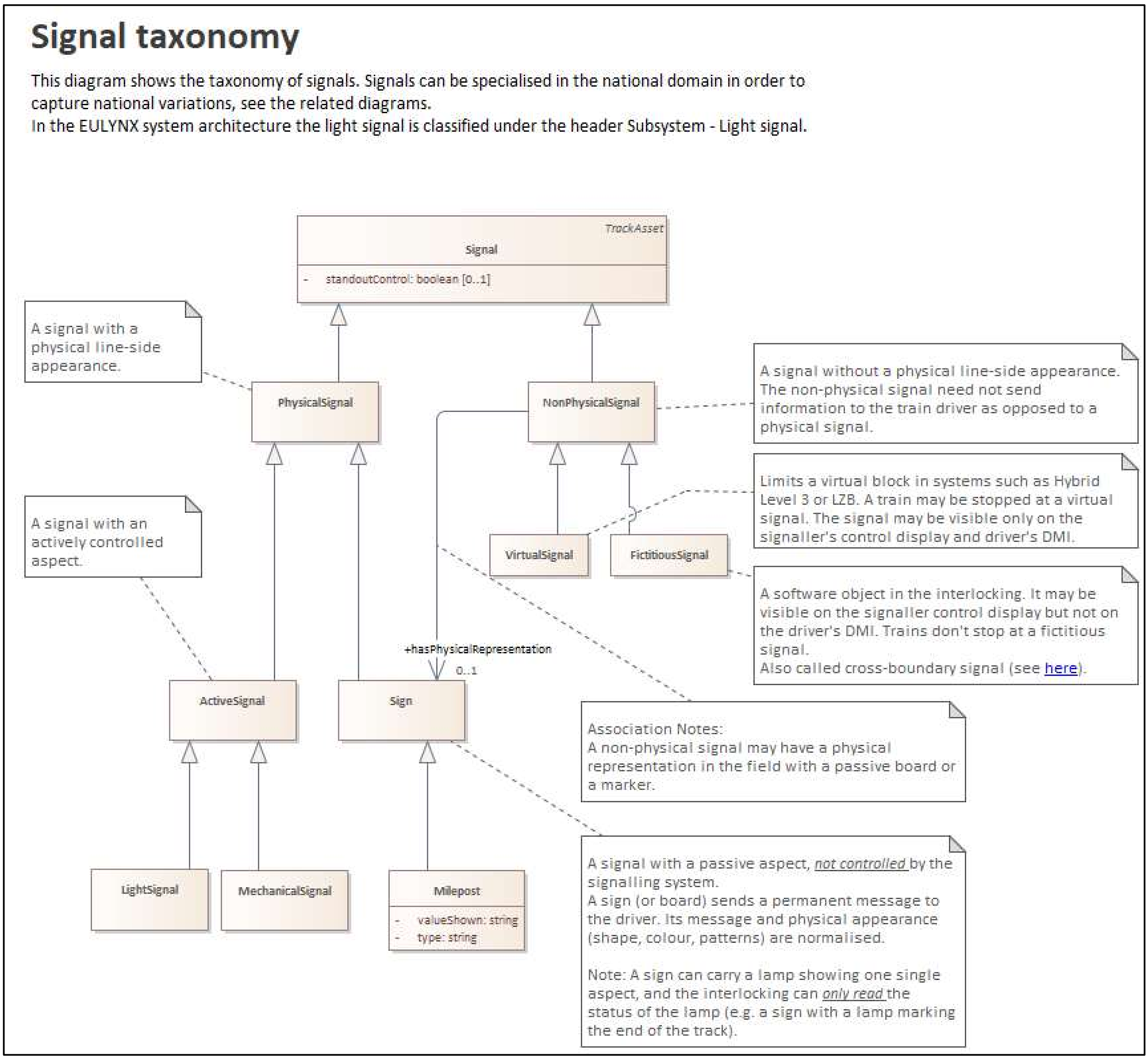

Figure 11: EULYNX Dataprep - Signal Taxonomy - [11]

7.2.1.1.7 As defined in [11], a light signal has one or more signal frames.

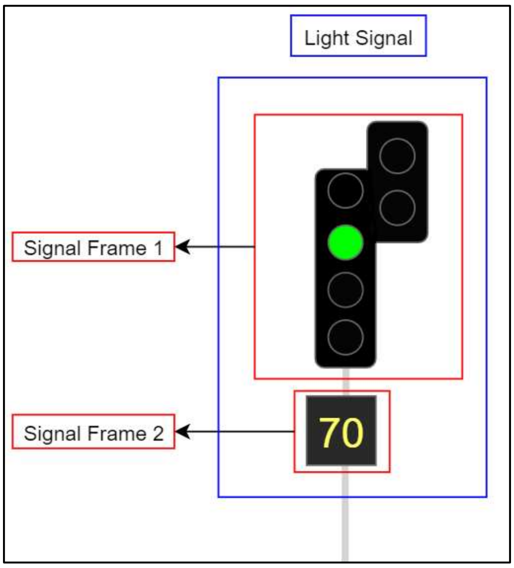

Figure 12: A light signal and its signal frames

7.2.1.1.8 As defined in [11], a signal frame has an aspect that is either passive or active, i.e. that can change aspect.

7.2.1.1.9 A light signal and its signal frames are described in the Signalling Profile of the Digital Map, via the light signal information, defined in 7.4.3.

7.2.1.1.10 A signal frame location is given by a point of reference. Location attributes of this point of reference are defined in 7.4.3.

7.2.1.1.11 The signal frame's point of reference is the intersection of straight lines of the most upper part and most left part of the signal frame, when facing the front side of the signal frame.

7.2.1.1.11.1 This point of reference is called signal frame reference point in the document.

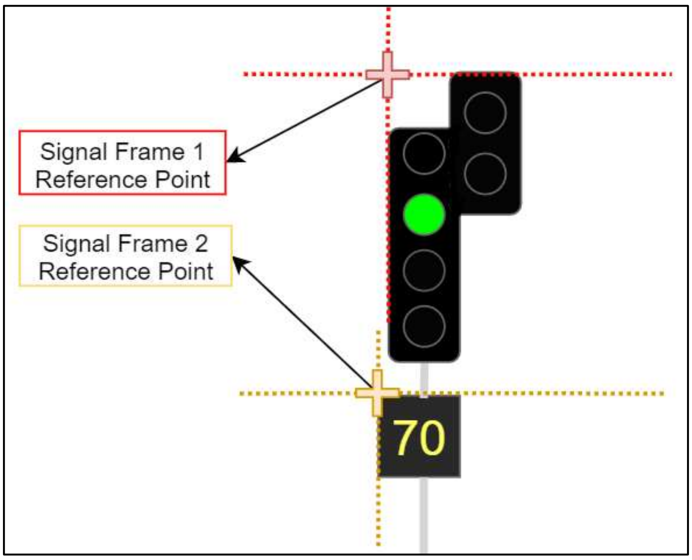

Figure 13: Signal frame reference points of two signal frames of a light signal

NOTE 1: It is also possible to combine all the frames of a given mast, into one unique frame. This choice is application specific and is not further specified in the present document.

NOTE 2 : Frames of a given mast shall remain independent if their aspects have no logical link between them (which is the case in the Figure 13, showing a French signal with first frame indicating 'proceed' and a second frame with a speed indicator '70 km/h').

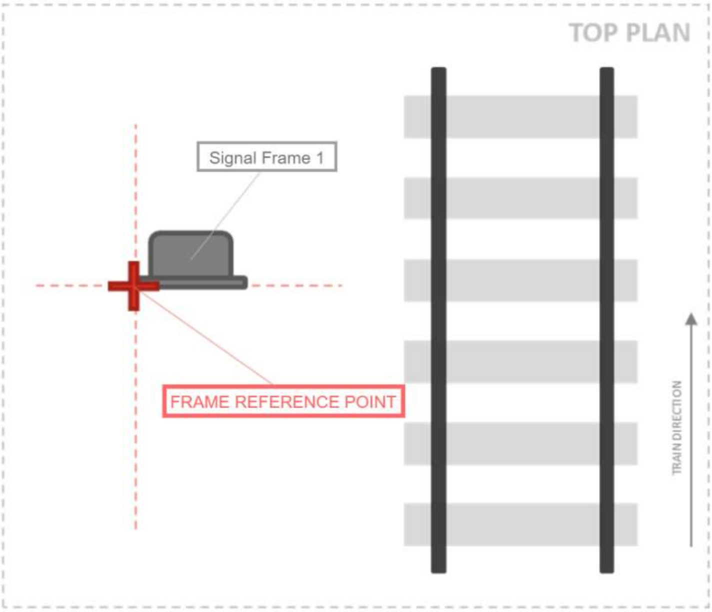

Figure 14: Signal frame reference point, top plan

7.3 VIRTUAL ETCS AREA

7.3.1.1.1 A virtual ETCS area is an area where SCV emulates ERTMS/ETCS trackside equipment.

7.3.1.1.2 A virtual ETCS area can be of two types:

- Without signal detection, where SCV is capable of providing ERTMS/ETCS data contained in the Digital Map, based on the localization of the train.
- With signal detection, where SCV is capable of providing ERTMS/ETCS data contained in the Digital Map, based on the localization of the train, and on the light signal aspect.

7.3.1.1.3 A virtual ETCS area without signal detection emulates fixed Eurobalises in ERTMS/ETCS Levels 1, 2 and 3.

7.3.1.1.4 A virtual ETCS area with signal detection emulates trackside ERTMS/ETCS Level 1 (LEU and Eurobalises).

7.3.1.1.4.1 NOTE: Some physical Eurobalises may be still required for relocation purposes. This is out of the scope of the concept.

7.3.1.1.5 An area is considered as a virtual ETCS area when:

- This area has been studied via an application engineering process, to create all required ERTMS/ETCS data, described in 7.4.2,
- This area has been studied via an application engineering process, to create all required light signal information, if any, described in 7.4.3,
- This area has been studied via an application engineering process (see 7.1.2.2), to create all required data for localisation to provide absolute train positioning,

- This area is under the responsibility of one or several Operational Execution entities, capable of providing a Journey Profile,
- This area is under the responsibility of one or several Digital Map entities, capable of providing the ERTMS/ETCS data and light signal information via the Segment Profile,

7.3.1.1.6 A train is considered fit for purpose to run on a virtual ETCS area when:
- The train is equipped with an ERTMS/ETCS onboard,
- The train is equipped with REP,
- The train is equipped with Localization,
- The train is equipped with SCV,
- The train is equipped with PER, if the virtual ETCS area is with signal detection,

7.4 VIRTUAL INFORMATION POINT

7.4.1 Introduction

7.4.1.1.1 Virtual Information Points (VIP) result of the virtualization of current Information Points.

7.4.1.1.2 VIP are placed in the Signalling Profile of the Digital Map as defined in 7.1.2.3.

7.4.1.1.3 A VIP shall contain the following Information:
a) Position in the Signalling Profile,
b) If any, light signal Information as defined in 7.4.3,
c) ETCS Information, as defined in 7.4.2.
d) Unique identification.

7.4.1.1.4 The position in the Signalling Profile is the distance of the VIP from the beginning of the Signalling Profile containing the VIP.

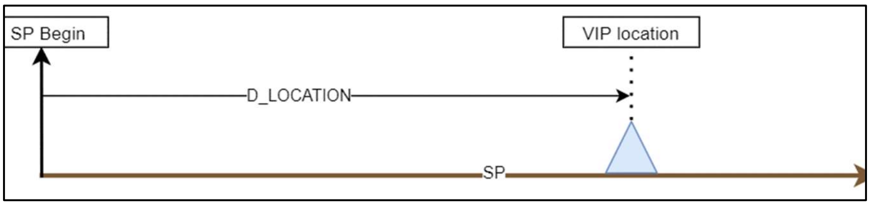

Figure 15: VIP Location

7.4.2 ETCS Information

7.4.2.1.1 ETCS Information is stored in a VIP.

7.4.2.1.2 ETCS Information is composed of a set of virtual ETCS telegrams, as defined hereafter.

7.4.2.2 Virtual ETCS telegrams

7.4.2.2.1 Two types of virtual ETCS telegrams are considered:
- “Fixed ETCS telegrams”, which contain ETCS data, to be sent to Train Protection, that are not related to a signal aspect.
- “ETCS telegrams associated with signal aspect” which contain ETCS data to be sent to Train Protection, only if the target light signal presents a possible signal aspect.

7.4.2.2.1.1 NOTE: possible signal aspect is defined in 7.4.3.1.9.

7.4.2.2.2 A Virtual ETCS telegram is composed of the following information:

- The position where its ETCS data shall be in the Virtual ETCS Message: N_PIG,
- The number of sets of ETCS data to be gathered, to compute the virtual ETCS message: N_TOTAL,
- A set of sorted ERTMS/ETCS packets, named ETCS Data in this document. (cf. 7.4.2.3)

7.4.2.2.3 ETCS telegrams associated with signal aspect contain the following additional information:

- The identifier of the associated signal aspect: M_SIGNAL_ASPECT,
- The qualifier to indicate if its ETCS Data is infill or main information: Q_INFILL.

7.4.2.3 ETCS Data

7.4.2.3.1 ETCS Data may be composed of the current ERTMS/ETCS packets defined in [1] chapter 7.

7.4.2.3.2 A new packet may be defined to enable Train Protection to be provided with Linking Information to BG and VIP. This new packet is defined in 11.5.1.

7.4.2.4 ETCS Information data model

7.4.2.4.1 The ETCS Information data model is a part of Signalling library, as described in the model [10], associated to a VIP.

7.4.2.4.2 The figure below describes the ETCS Information data model:

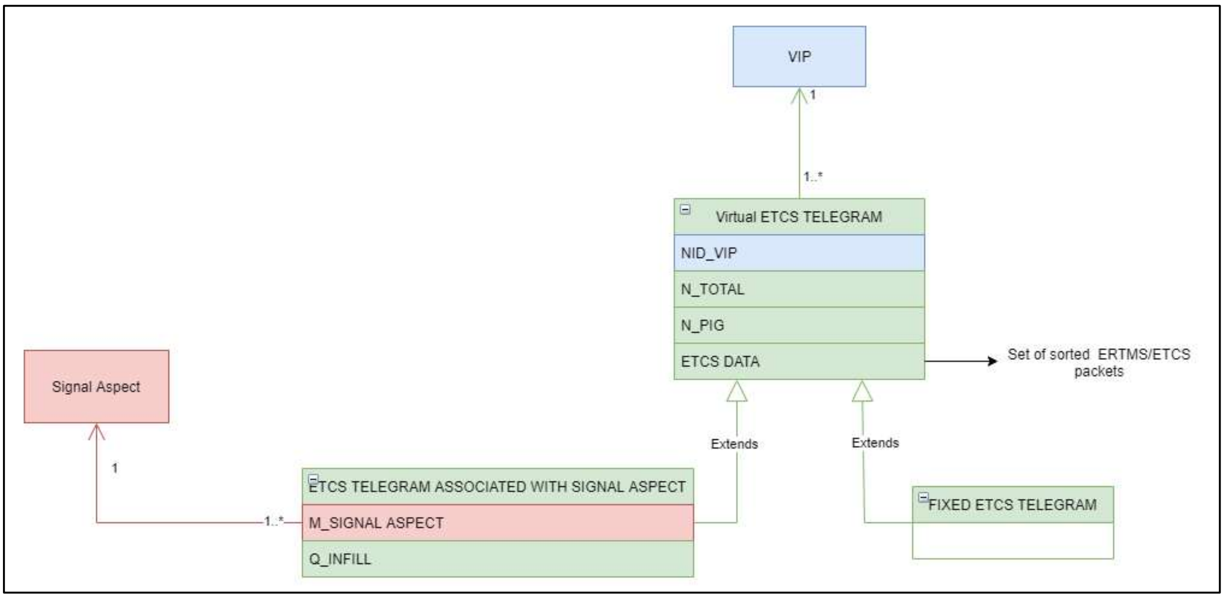

Figure 16: ETCS Information data model

7.4.2.4.2.1 NOTE 1: As shown in the figure, the VIP can contain one to several Virtual ETCS telegrams.

7.4.2.4.2.2 NOTE 2: As shown in the figure, Virtual ETCS telegrams can be fixed or associated with a possible signal aspect.

7.4.3 Light signal Information

7.4.3.1.1 A light signal can be associated with a VIP.

7.4.3.1.2 Information about light signals is placed in the VIP.

7.4.3.1.3 The Light Signal Information data model is a part of Signalling library, as described in the model [10], associated to a VIP.

7.4.3.1.4 Light signal Information shall contain:

a) Information about the acquisition method of the signal aspect,
b) Infill area information,
c) Signal aspect Information.
d) Light signal visibility area information,
e) Signal frames description.

7.4.3.1.5 The way to detect the signal aspect is described using Q_ACQUIRE variable, see 9.2.3.1.1.

7.4.3.1.6 Infill area is an area where SCV can provide a Movement Authority as infill information to Train Protection. It is defined with a start location and an end location, in the coordinate system of the segment. (See [1] §3.6.2.3).

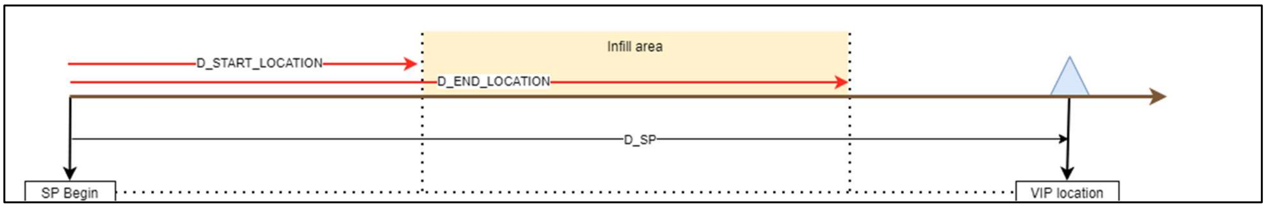

Figure 17: Infill area description

7.4.3.1.6.1 NOTE: This is to delimitate the area where SCV is allowed to send infill information to Train Protection.

7.4.3.1.7 Light signal visibility area is the area where the light signal associated to a VIP is considered as visible. It is defined with a start location and an end location, in the coordinate system of the segment.

7.4.3.1.7.1 The aim is to have a long enough distance to enable the train to perceive the signal aspect over a long enough period to detect blinking and to detect a change of the signal aspect whereas the train is approaching the light signal. Nevertheless, the distance shall be short enough to avoid false detection.

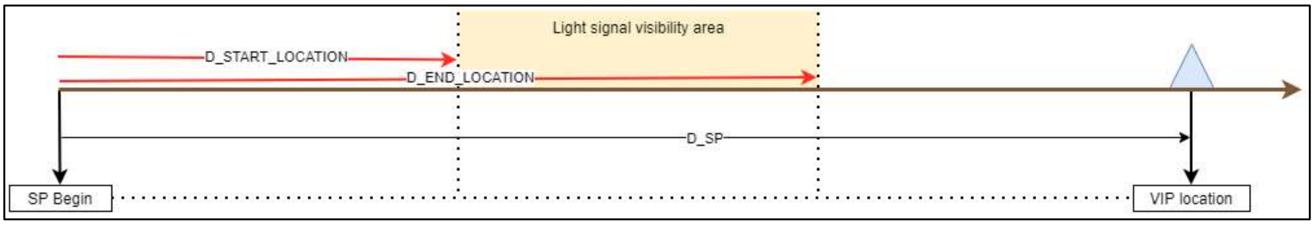

Figure 18: Light signal visibility area description

7.4.3.1.8 Each signal frame is defined by the following Information in the signalling library (see §10):

a) The type of signal frame, thanks to NID_ FRAME_TYPE value,
b) The coordinates of the signal frame reference point (see 7.2.1.1.11) defined with variables: M_ FRAME_LATITUDE, M_FRAME_LONGITUDE and M_ FRAME_ALTITUDE.

7.4.3.1.9 A possible signal aspect is an aspect that can be displayed by the light signal and for which a Virtual ETCS telegram is associated.

7.4.3.1.10 All the possible signal aspects shall be contained in the VIP.

7.4.3.1.10.1 A possible signal aspect can have an identifier within the VIP to be associated with ETCS telegrams, named M_SIGNAL_ASPECT.

7.4.3.1.10.2 The possible signal aspects shall use the Signal Vector format, as defined in 7.5.

7.4.3.1.10.3 The figure below shows the light signal data model:

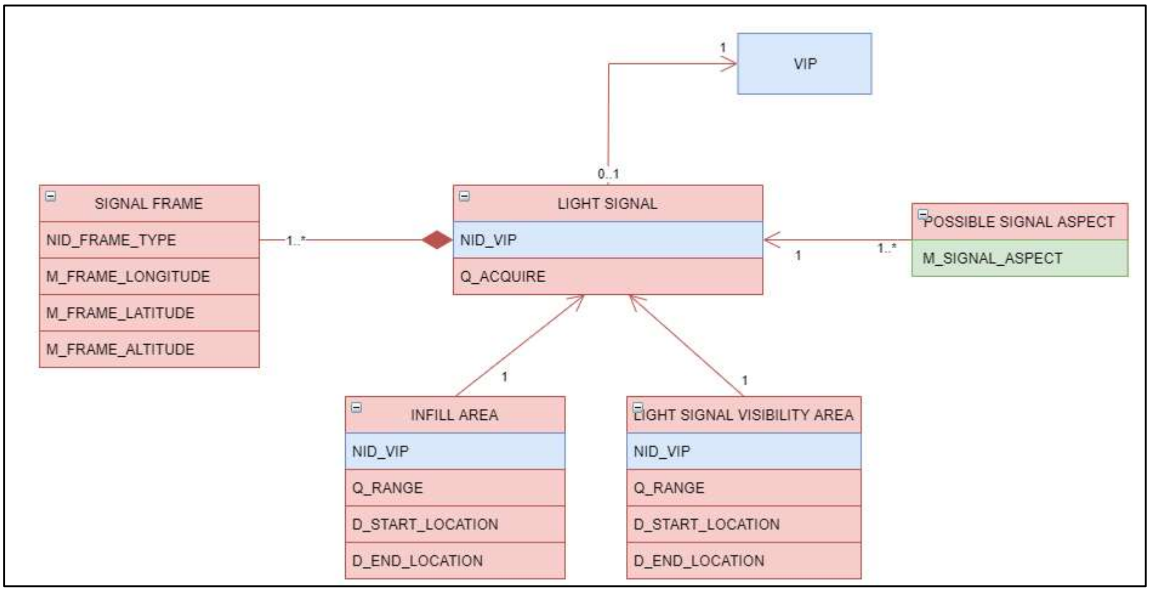

Figure 19: Light signal data model

7.5 SIGNAL VECTOR

7.5.1.1.1 EULYNX Signal Vector is a format, defined in [6], determining the lineside signal aspects requested by the interlocking to the light signal.

7.5.1.1.2 In this concept, the EULYNX Signal Vector format is used to:

- transmit the frame aspect, as defined in 7.9.1.1.5,
- to store all possible signal aspects of a given light signal, in the Digital Map,
- and to transmit the Expected Signal Aspect from the trackside via REP.

RATIONALE: Light signal aspects are country specific and have to be transmitted in a standard interface between modules PER and SCV. Therefore, a standardisation activity of all national light signal aspects has to be done before the creation of this standard interface. EULYNX Signal Vector principle, combined with the Signal Aspect Table, provides an already performed standardisation of national light signal aspects. This work is wisely reused in this concept.

7.5.1.1.3 EULYNX Signal Vector is described in [6] and main specifications are following:

- [Eu.DK.254]:
  The signal vector consists of 6 byte of information. The following diagram displays the structure of the signal vector.
- [Eu.DK.255]:

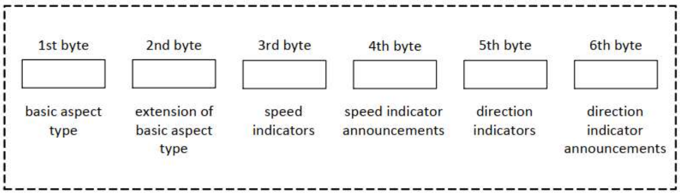

Figure 20: Signal Vector

- [Eu.DK.257]:
  The 6 bytes of the signal vector represent the following information:
  - **First byte**: code for basic aspect type,
  - **Second byte**: code for extension of basic aspect types,
  - **Third byte**: speed indicators,
  - **Fourth byte**: speed indicator announcements,
  - **Fifth byte**: direction indicators,
  - **Sixth byte**: direction indicator announcements,
- [Eu.DK.258]:
  The meaning of each byte value and the relation to corresponding national aspects can be found in the signal aspect table [Eu.Doc.37], reference document [6].
- [Eu.DK.259]:
  The bytes of the signal vector are independent. As an example, the speed indicator byte can take any value described in the signal aspect table, independent of the value of the bytes for the basic aspect, extension, speed indicator announcements and direction indicators. Configuration and engineering data define combinations of the signal vector byte values constitute a valid signal aspect at an individual signal.

7.5.1.1.4 Each byte of the signal vector corresponds to an atomic aspect of the signal aspect.

7.5.1.1.5 For each byte of the signal vector, the value “0x00” is added and used for no detection, i.e. when PER is not able to provide the signal aspect.

7.5.1.1.6 In reference document [9], 7 countries are covered by the EULYNX Signal Aspect Table.

7.5.1.1.7 Studies on EULYNX project shall be performed to continue the standardization activity of the Signal Aspect Table.

7.5.1.1.8 For a given project or a given line, it shall be analysed if all signals aspects are covered by the EULYNX Signal Aspect Table.

7.6 TARGET LIGHT SIGNAL

7.6.1.1.1 The target light signal is the next light signal expected by the train according to the list of Signalling Profiles referenced by the JP.

7.6.1.1.2 The target light signal is the light signal for which a signal aspect is expected by SCV.

7.6.1.1.3 The target signal aspect is the signal aspect returned by the SCV function "acquire signal aspect".

7.6.1.1.4 The target light signal is the light signal provided in the Signal Detection Request from SCV to PER, as defined in 7.8.

7.6.1.1.5 The target light signal is the light signal for which a Signal Detection Response is expected from PER to SCV, as defined in 7.9.

7.7 TRACK VERTICES

7.7.1.1.1 A vertex is a point with a very precise location in GNSS coordinates.

7.7.1.1.2 Track vertices are described in [2].

7.7.1.1.3 The figure below shows a segment with a certain number of vertices modelled with red dots.

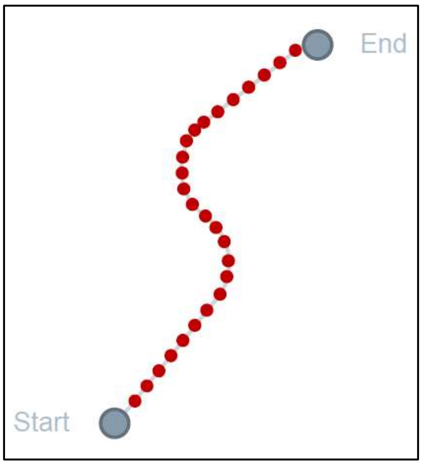

Figure 21: Track vertices

7.7.1.1.4 These vertices permit a very precise modelling of the track in 3D coordinates, a polyline linking the vertices aligned with the track centre and at the level of the tread of the rail.

7.7.1.1.5 Track Vertices are placed in the Geometry Profile, as defined in [10].

7.7.1.1.6 The Light Signal Vertex is the Track Vertex which has the same 1D position as the VIP in the associated segment, according to the common topological profile, see 11.1.2.2.3.

7.8 Signal Detection Request

7.8.1.1.1 The Signal Detection Request is the SCV interrogation to PER for the aspect of the target signal.

RATIONALE 1: Activating the perception module by request limits the continuous perception of the physical environment and false positives.

RATIONALE 2: as the positions of the signals is known, the absence of information at the passing of the signal is an information. If PER does not provide an answer to SCV when the train has passed the signal, then the most restrictive information can be applied.

7.8.1.1.2 The exchange scenario of the signal detection request is in the figure below.

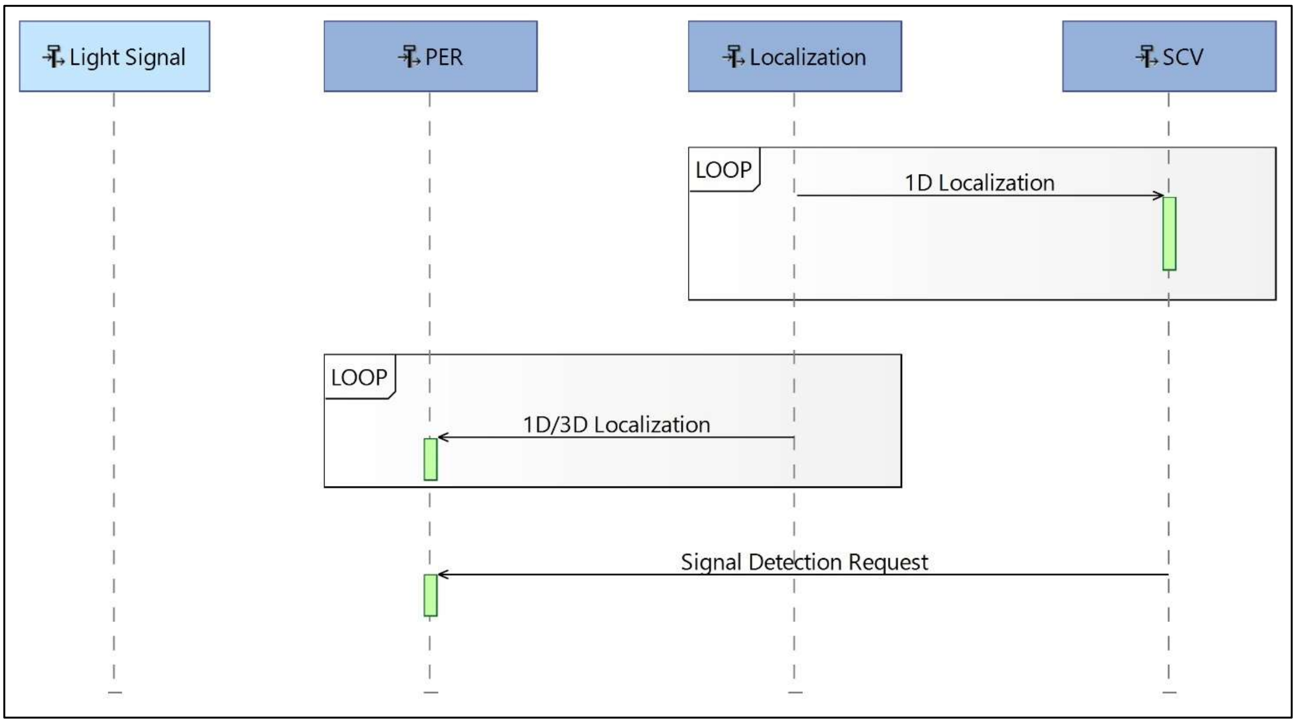

Figure 22: Exchange scenario, signal detection request

7.8.1.1.3 A signal detection request is initialized or cancelled using Q_SDRINIT variable.

7.8.1.1.4 The Signal Detection Request is composed of the following information:

a) Country identifier: NID_C,
b) Qualifier to initialize or cancel a Signal Detection Request: Q_SDRINIT.

7.8.1.1.5 If Q_SDRINIT != 0, then the Signal Detection Request is initialized and the additional following information is sent by SCV to PER:

a) Number of signal frames of the target light signal: N_FRAME_ITER,
b) Identity number of the panel type of the signal frame(k): NID_FRAME_TYPE,
c) GNSS latitude coordinate in WGS84 of the signal frame(k): M_FRAME_LATITUDE,
d) GNSS longitude coordinate in WGS84 of the signal frame(k): M_FRAME_LONGITUDE,

e) GNSS ellipsoid altitude coordinate in WGS84 of signal frame(k): M_FRAME_ALTITUDE,
f) Number of track vertices to be sent N_CMMAP_ITER,
g) GNSS latitude coordinate WGS84 of the track vertex (n): M_CMMAP_LATITUDE (n),
h) GNSS longitude coordinate WGS84 of the track vertex (n): M_CMMAP _LONGITUDE (n),
i) GNSS ellipsoid altitude coordinate WGS84 of the track vertex (n): M_CMMAP _ALTITUDE (n).

RATIONALE: properties of the signal are invariants. They are transmitted to PER so to narrow the responsibility of the perception module and enhance performance.

7.8.1.1.6 NID_FRAME_TYPE defines a type of signal frame, composed of the following attributes:

- the shape of the signal frame,
- the number of lamps and their position in the signal frame,

7.8.1.1.7 The combination (NID_ FRAME_TYPE; NID_C) is a unique identifier for a signal frame type associated with a given implementation of lamps, providing all possible aspects.

NOTE: In this application engineering process, it is suitable to provide all possible signal vectors for a given NID_FRAME_TYPE. Atomic aspects of the signal vector that are not provided by the given frame type can be filed with value 0xFF in the application engineering phase.

RATIONALE: This provides the PER supplier with all possible aspects and possible signal vectors for a given frame type, for PER development.

7.8.1.1.8 In this concept, NID_FRAME_TYPE is to be defined at project level.

7.8.1.1.9 European standardization of NID_FRAME_TYPE can be performed in further projects.

7.8.1.1.10 The track vertices are ordered successively, from the Light Signal Vertex (see 11.1.2.2.3.) to the current front end of the train when the signal detection request is initialized.

7.9 Signal Detection Response

7.9.1.1.1 The Signal Detection Response is the PER response to the SCV Signal Detection Request.

7.9.1.1.2 The exchange scenario of the signal detection response is in the figure below.

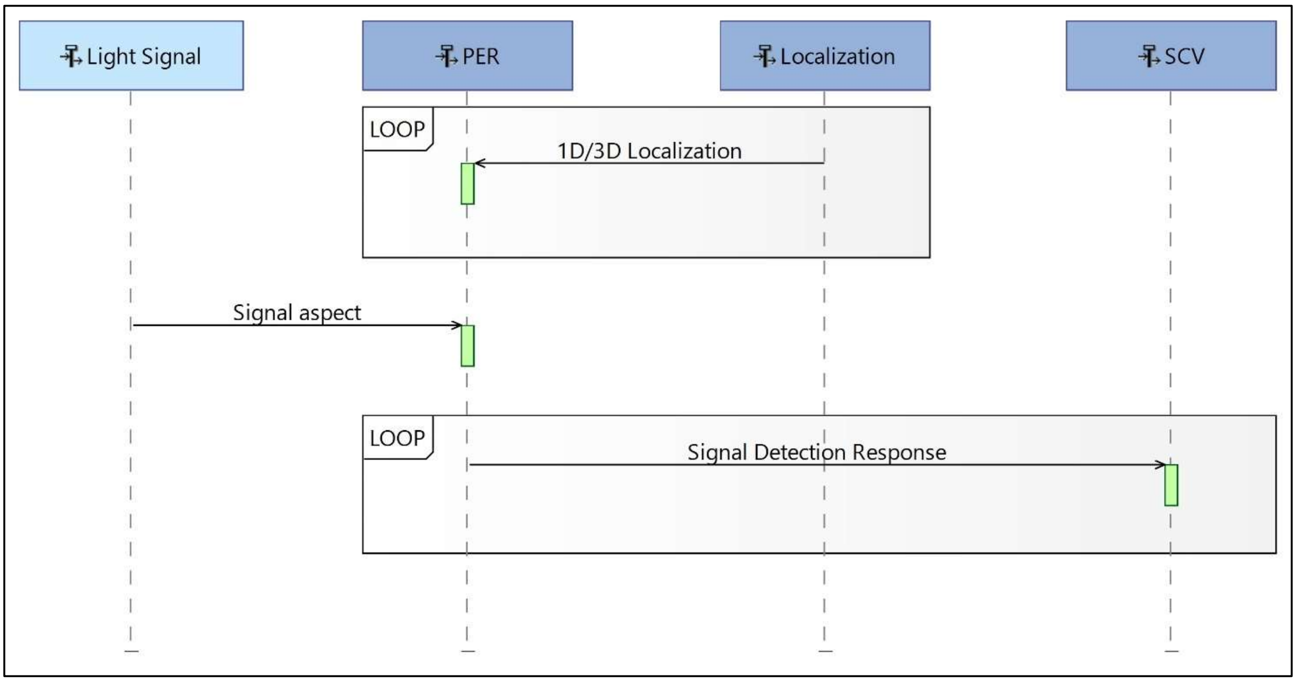

Figure 23: Exchange scenario, signal detection response

7.9.1.1.3 The Signal Detection Response is composed of following information:

a) Country identifier: NID_C,
b) Unique identity number of the target light signal: NID_VIP,
c) Number of signal frames of the target light signal: N_FRAME_ITER,
d) Identity number of the type of the signal frame(k): NID_FRAME_TYPE,
e) Frame aspect(k),
f) Detection confidence of the frame aspect: M_DETECTION_CONFIDENCE(k).

RATIONALE: the repetition of the static information is a mechanism that ensures SCV that PER has received the correct static information in the Signal Detection Request.

7.9.1.1.4 For each signal frame composing the target light signal, PER shall return a frame aspect using the Signal Vector as defined in 7.5.

7.9.1.1.4.1 NOTE: The Signal Detection Response uses the Signal Vector to describe a frame aspect and not Signal Aspect unlike EULYNX Concept as defined in [6] §6.1.2.

7.9.1.1.5 The figure below shows an example of frame aspects returned in the Signal Detection Response:

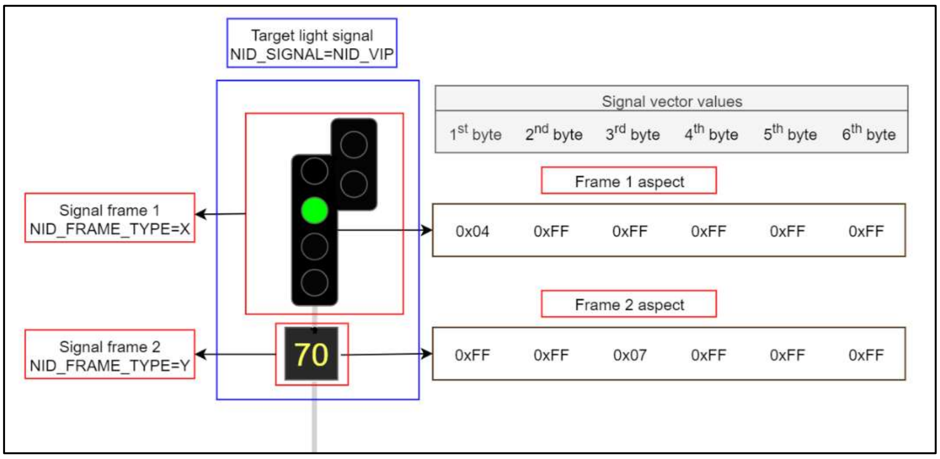

Figure 24: Example of Signal Detection Response data

- This figure illustrates a target light signal, whose identifier is NID_VIP.
- This target light signal is composed of two signal frames, so N_ITER=1.

Thus, the Signal Detection Response shall contain the identifier of the light signal and the two detected frame aspects, using the signal vector. Each frame aspect is associated with the type identifier NID_FRAME_TYPE of its signal frame.

7.9.1.1.6 M_DETECTION_CONFIDENCE is a binary variable.

7.9.1.1.6.1 When M_DETECTION_CONFIDENCE == 0, then the frame aspect provided by PER is considered as non-safe by PER.

7.9.1.1.6.2 When M_DETECTION_CONFIDENCE == 1, then the frame aspect provided by PER is considered as safe by PER.

7.9.1.1.7 Detailed specification of M_DETECTION_CONFIDENCE shall be done in further projects.

7.10 Expected Signal Aspect Request

7.10.1.1.1 Signal aspects can be known by trackside subsystems i.e. Traffic Management System or Interlocking.

7.10.1.1.2 As defined in 7.1.1, OE is the trackside component enabling the transmission of dynamic information to REP and related to the JP.

7.10.1.1.3 If the signal aspect information is available trackside, then OE can retrieve it and forward to REP the signal aspects of all signals in the route of the JP.

7.10.1.1.4 Each time a signal aspect changes, OE transmits the new signal aspect to REP.

7.10.1.1.5 Therefore, REP is in possession of the signal aspects of all signals within the route of the JP.

7.10.1.1.6 This information can be used by SCV in combination with the signal aspect provided by PER.

7.10.1.1.7 The Expected Signal Aspect Request is the SCV interrogation to REP for the aspect of the target signal.

7.10.1.1.8 The expected signal aspect request is composed of following information:

a) Unique identity of the target light signal: NID_VIP.

7.11 Expected Signal Aspect Response

7.11.1.1.1 The Expected Signal Aspect Response is the REP response to the SCV Expected Signal Aspect Request.

7.11.1.1.2 The Expected Signal Aspect Response is composed of the following information:

a) The timestamp when the signal aspect was provided by OE: T_DATA,
b) Unique identity number of the target light signal: NID_SIGNAL (=NID_VIP),
c) The Expected Signal Aspect, using signal vector,
d) The confidence, using M_EXPECTED_CONFIDENCE.

7.11.1.1.3 M_EXPECTED_CONFIDENCE is a variable provided by OE, indicating if the Expected Signal Aspect is considered by OE as safe or non-safe.

RATIONALE: For some countries having already upgraded their trackside equipment (i.e. interlocking and/or Traffic Management System), the aspect of the signals can be retrieved with a safety integrity level.

7.11.1.1.4 M_EXPECTED_CONFIDENCE relates to trackside equipment and shall be defined in further projects.

7.11.1.1.5 The exchange scenario of the Expected Signal Aspect Request and Response in in the figure below.

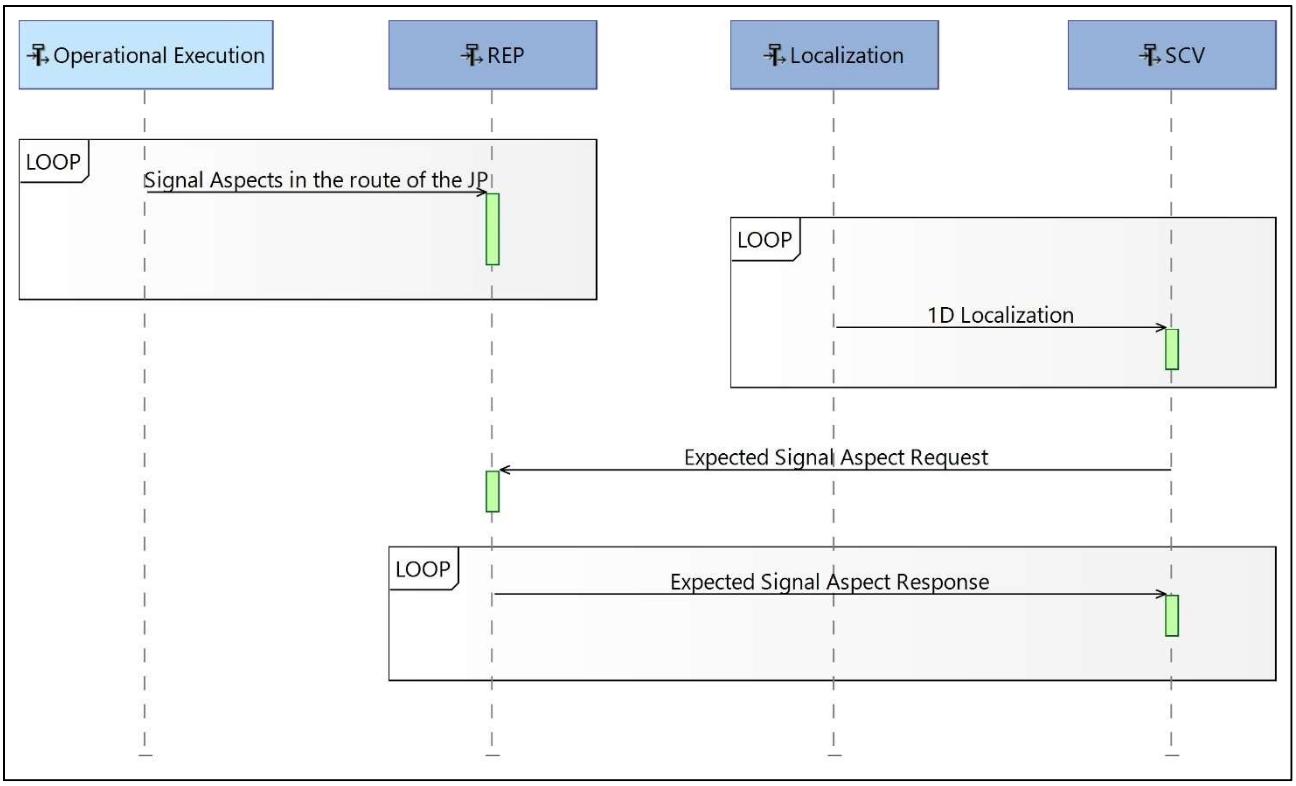

Figure 25: Exchange scenario, Expected Signal Aspect Request and Response

7.12 Virtual ETCS Message

7.12.1.1.1 The Virtual ETCS Message is the ETCS data sent by SCV to Train Protection.

7.12.1.1.2 The Virtual ETCS Message is built gathering ETCS data of fixed ETCS telegrams and telegrams associated with the target signal aspect.

7.12.1.1.3 The Virtual ETCS Message is composed of following information:

a) Time Stamp when information was computed: T_DATA,
b) SCV Message Identifier: NID_MESSAGE,
c) Identifier of the VIP: NID_VIP,
d) NID_C
e) Length of the message: L_MESSAGE,
f) ETCS Data.

8 PER DESCRIPTION

8.1 PER AND ITS ENVIRONMENT

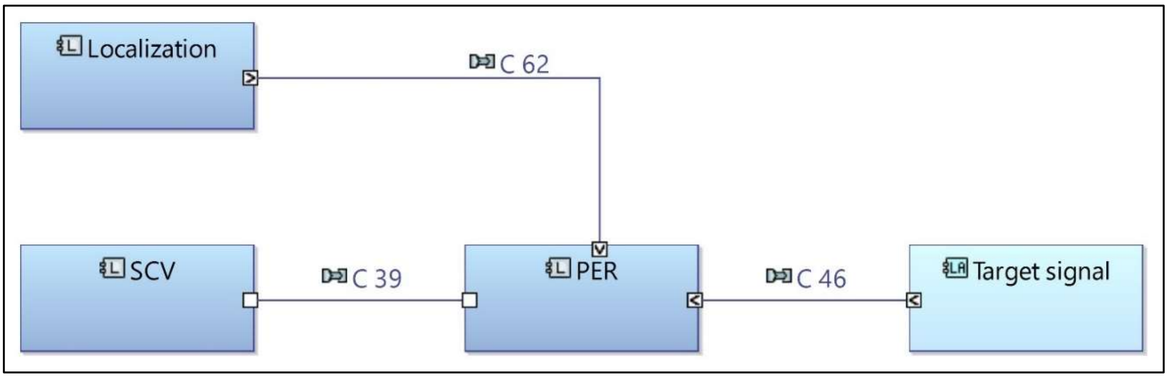

Figure 26: PER interfaces

8.1.1.1.1 PER extracts the target frame aspects from the physical environment.

8.1.1.1.2 C46 is the visual interface between PER and the target light signal.

8.1.1.1.3 PER provides the target light signal aspect to SCV.

8.1.1.1.4 C39 is the interface between PER and SCV.

8.1.1.1.5 C62 is the interface between PER and Localization.

8.2 PER FUNCTIONAL REQUIREMENTS

8.2.1 Generic requirements

8.2.1.1.1 PER shall determine its state.

8.2.2 Read target signal aspect (RTSA)

8.2.2.1 Generic requirements

8.2.2.1.1 PER shall retrieve from SCV the active cab.
RATIONALE: This is to ensure that PER activates the proper sensors.

8.2.2.1.2 PER shall determine the status the function RTSA.
8.2.2.1.2.1 The different states of the function RTSA are:

a) Not Available: RTSA waits for all necessary inputs to be available,
b) Available: RTSA is ready for signal detection,
c) Active: RTSA is extracting the target signal aspect,
d) Failure: fulfilling the function RTSA is not possible.

8.2.2.1.3 The conditions of transition between the states are defined below:

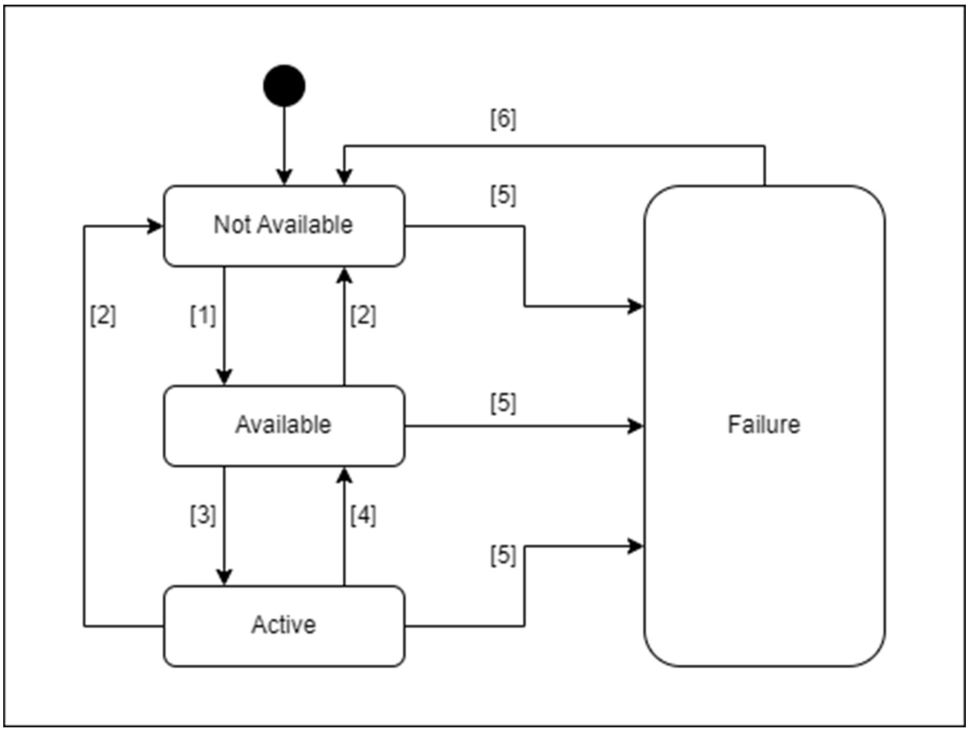

Figure 27:Status and transitions of the function RTSA

Cd ID	Content of the conditions
[1]	PER has established communication with Localization and retrieved the train localization, AND PER has established communication with SCV.
[2]	PER has lost the communication with localization, OR PER has lost the communication with SCV.
[3]	PER has received a Signal Detection Request with Q_SDRINIT==1 from SCV.
[4]	PER has received a Signal Detection Request with Q_SDRINIT==0 from SCV.
[5]	An internal PER error makes it unable to fulfill the function *Read Target Signal Aspect.*
[6]	PER has recovered the function *Read Target Signal Aspect.*

Table 4: Condition transition table

8.2.2.1.4 The state of the RTSA function is provided by M_PER_RTSA_STATUS.

8.2.2.1.5 If RTSA is in state available, then M_PER_RTSA_STATUS is AVAILABLE.

8.2.2.1.6 If RTSA is in state active, then M_PER_RTSA_STATUS is ACTIVE.

8.2.2.1.7 If RTSA is in state failure, then M_PER_RTSA_STATUS is in FAILURE.

8.2.2.1.8 If RTSA is in state not available, then M_PER_RTSA_STATUS is NOT AVAILABLE.

8.2.2.1.9 When the function RTSA is active, then PER shall detect each frame aspect of the target light signal.

8.2.2.1.9.1 PER shall detect basic aspect types as defined in the signal vector.

8.2.2.1.9.2 PER shall detect extensions of basic type aspects as defined in the signal vector.

8.2.2.1.9.3 PER shall detect speed indicators as defined in the signal vector.

8.2.2.1.9.4 PER shall detect speed indicators announcements as defined in the signal vector.

8.2.2.1.9.5 PER shall detect direction indicators as defined in the signal vector.

8.2.2.1.9.6 PER shall detect direction indicators announcements as defined in the signal vector.

8.2.2.1.10 When the function RTSA is active, then PER shall build the frames aspects according to [9].

8.2.2.1.10.1 PER shall associate the perceived basic aspect type, with its corresponding EULYNX code provided in [9].

8.2.2.1.10.2 PER shall associate the perceived extensions of basic type aspect, with its corresponding EULYNX code provided in [9].

8.2.2.1.10.3 PER shall associate the perceived speed indicators, with its corresponding EULYNX code provided in [9].

8.2.2.1.10.4 PER shall associate the perceived speed indicators announcements, with its corresponding EULYNX code provided in [9].

8.2.2.1.10.5 PER shall associate the perceived direction indicators, with its corresponding EULYNX code provided in [9].

8.2.2.1.10.6 PER shall associate the perceived direction indicators announcement, with its corresponding EULYNX code provided in [9].

8.2.2.1.10.7 PER shall determine if the extraction of each target frame aspect is safe or not.

8.2.2.1.11 If the target frame aspect extraction is non-safe, then M_DETECTION_CONFIDENCE == 0.

8.2.2.1.12 If the target frame aspect extraction is safe, then M_DETECTION_CONFIDENCE == 1.

Rationale: while the function RTSA being active, a detected unexpected stop must be forwarded as soon as possible, and without waiting the information to be considered safe by PER.

8.2.2.2 Signal Detection Response

8.2.2.2.1 When the function RTSA is active, then PER shall send to SCV the Signal Detection Response every 50 ms.

RATIONALE: The light signal aspect can suddenly change during the train approach. Continuous perception and transmission to SCV is necessary until the passing of the light signal.

8.2.2.2.2 When the function RTSA is active, if PER is not yet able to provide a frame aspect, then PER shall complete the signal vector bytes of this frame aspect with 0x00 value as defined in 7.5.1.1.5.

8.2.2.2.2.1 When the function RTSA is active, if PER is able to extract a frame aspect as safe information, then PER shall fill the frame aspect and set the associated M_DETECTION_CONFIDENCE to “1”.

8.2.2.2.2.2 When the function RTSA is active, if PER is able to extract a frame aspect as non-safe information, then PER shall fill the frame aspect and set the associated M_DETECTION_CONFIDENCE to “0”.

8.2.2.2.3 When the function RTSA is active, if PER is unable to extract all atomic aspects of a frame aspect, then PER shall fill the frame aspect only with the values of the detected atomic aspects, and the undetected atomic aspects shall by filled with 0x00.

8.2.2.2.4 When the function RTSA is active, if PER is unable to extract all atomic aspects of a frame aspect, then M_DETECTION_CONFIDENCE == 0.

8.2.2.2.4.1 The example below illustrates how to build a Signal Detection Response:

- On the signal frame 1, PER extracts from the signal frame 1 a STOP/DANGER aspect. If the information is considered by PER as safe, then the associated M_DETECTION_CONFIDENCE is set to “1”.
- On the signal frame 2, PER is unable to extract the speed indicator aspect. Thus, it is set to 0x00 in the signal vector and its associated M_DETECTION_CONFIDENCE is set to “0”.

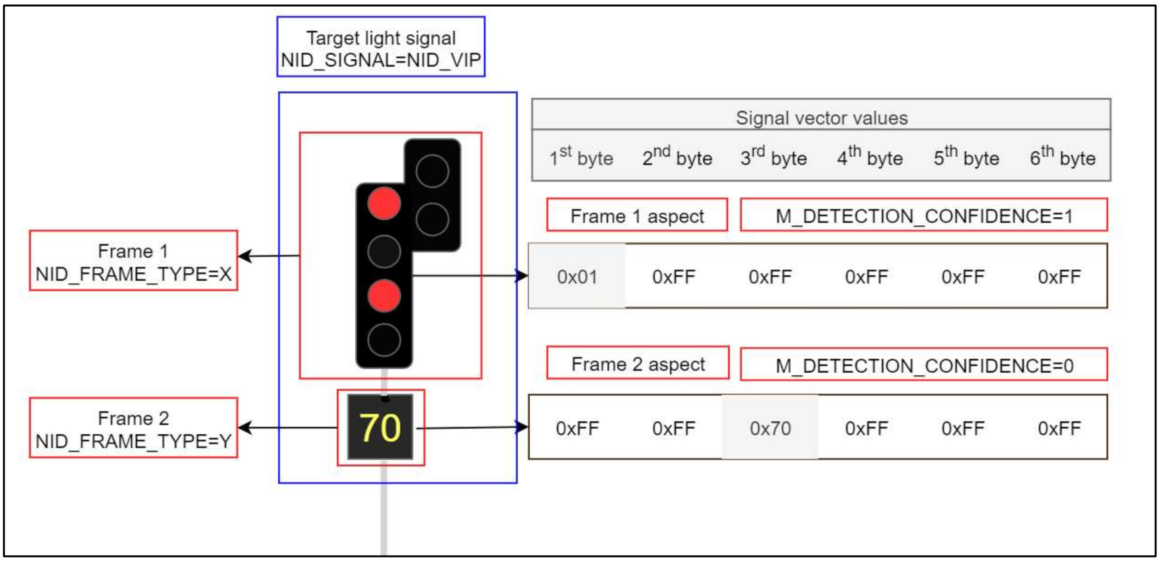

Figure 28: Unexpected STOP detected

8.2.2.2.5 The balance between safety and availability (false positives) shall be studied in further projects.

8.3 PER PERFORMANCE REQUIREMENTS

8.3.1.1.1 PER is responsible for the Signal Detection Response it gives to SCV.

8.3.1.1.2 Once PER estimates that M_PERCEIVED_CONFIDENCE == 1, then this variable shall not toggle.

8.3.1.1.3 The implementation of this threshold in PER is supplier specific.

8.4 PER INTERFACE REQUIREMENTS

8.4.1 Interface towards SCV (C39)

8.4.1.1.1 When the RTSA function is in state NOT AVAILABLE or AVAILABLE or ACTIVE, then PER shall send to SCV a PER_SCV_SIGNAL_DETECTION Packet (see 13.1.1.3) every 50 ms.

8.4.1.1.1.1 The Signal Detection Packet shall contain the status of the RTSA function: M_PER_RTSA_STATUS,

8.4.1.1.2 If M_PER_RTSA_STATUS == 1, then the Signal Detection Packet shall contain the Signal Detection Response (see 7.9).

8.5 PER STATE MACHINE

8.5.1.1.1 PER being a logical component fulfilling different perception functions, some of them being dealt outside TAURO work package 4.1, the state machine of PER shall be defined in a compatible way with all allocated functions.

8.5.1.1.2 This state machine shall be defined within X2RAIL4.

9 SCV DESCRIPTION

9.1 SCV AND ITS ENVIRONMENT

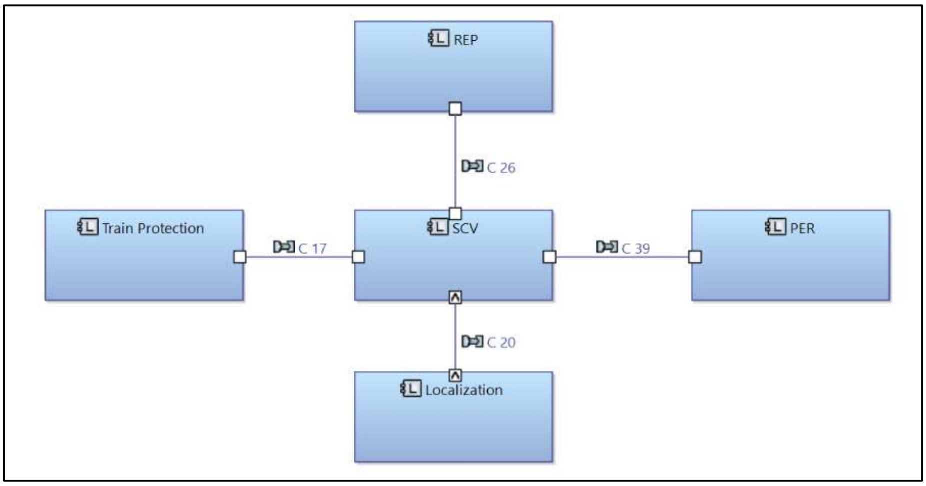

Figure 29: SCV interfaces

9.1.1.1.1 Localization provides SCV with navigation information.

9.1.1.1.2 C20 is the interface between SCV and Localization.

9.1.1.1.3 SCV provides PER with target light signal information.

9.1.1.1.4 PER provides SCV with target light signal aspect.

9.1.1.1.5 C39 is the interface between SCV and PER.

9.1.1.1.6 SCV gets from REP the Signalling Profile with the VIPs.

9.1.1.1.7 SCV gets from REP the Geometry Profile with the track vertices.

9.1.1.1.8 SCV gets from REP the Expected Signal Aspect when available.

9.1.1.1.9 C26 is the interface between SCV and REP.

9.1.1.1.10 SCV provides Train Protection with ETCS information.

9.1.1.1.11 C17 is the interface between SCV and Train Protection.

9.2 SCV FUNCTIONAL REQUIREMENTS

9.2.1 Introduction

9.2.1.1.1 SCV is the logical component that realizes the system function “Select and send ERTMS/ETCS data”.

9.2.1.1.2 SCV provides ERTMS/ETCS data contained in the VIP of the Signalling Profile, based on the localization of the train, and on the target light signal aspect.

9.2.1.1.3 The system function “Select and send ERTMS/ETCS data” is divided into three logical functions:

a) Retrieve localization and data base,

b) Acquire target signal aspect,

c) Provide ERTMS/ETCS data.

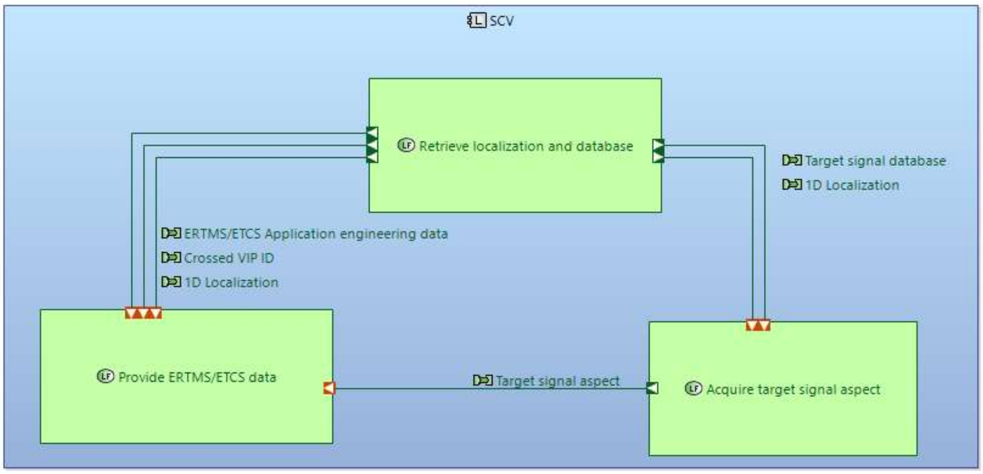

Figure 30: SCV logical functions

9.2.1.1.4 If there is no light signal information in the VIP, then the function “Acquire target signal aspect” is not used.

9.2.2 Retrieve localization and database

9.2.2.1 Generic requirements

9.2.2.1.1 SCV shall retrieve the Signalling Profile from REP.

9.2.2.1.2 SCV shall retrieve the Geometry Profile from REP.

9.2.2.1.3 SCV shall retrieve the navigation information from Localization.

9.2.3 Acquire target signal aspect

9.2.3.1 Generic requirements

9.2.3.1.1 SCV shall determine how the target light signal aspect shall be acquired, considering the Q_ACQUIRE variable as defined in 7.4.3.1.5.

9.2.3.1.1.1 If Q_ACQUIRE == 0, then the SCV logical function “Acquire light signal aspect” shall acquire the Perceived Signal Aspect from PER as defined in 9.2.3.3.

9.2.3.1.1.2 If Q_ACQUIRE == 1, then the SCV logical function “Acquire target signal aspect” shall acquire Expected Signal Aspect from REP and acquire Perceived Signal Aspect from PER as defined in 9.2.3.4.

9.2.3.2 Acquire Expected Signal Aspect

9.2.3.2.1 When the train enters the infill area of the next VIP, and Q_ACQUIRE == 1 for the target signal associated with the next VIP, then SCV shall initialize an expected signal aspect request to REP as defined in 7.10.

9.2.3.2.2 SCV shall initialize the Expected Signal Aspect Request to REP with Q_ESARINIT == 1.

9.2.3.2.3 SCV shall stop the Expected Signal Aspect Request to REP, at the passing of the VIP, with Q_ESARINIT == 0.

9.2.3.2.4 If the NID_VIP of the Expected Signal Aspect Response is different from the NID_VIP in the Expected Signal Aspect Request, then SCV shall discard the Expected Signal Aspect Response.

9.2.3.2.5 SCV shall check that the Expected Signal Aspect provided by REP for the target signal is a possible aspect contained in the VIP of the target signal.

9.2.3.2.6 If the Expected Signal Aspect provided by REP for the target signal is not a possible aspect contained in the VIP of the target signal, then SCV shall discard the Expected Signal Aspect received by REP.

9.2.3.3 Acquire Perceived Signal Aspect

9.2.3.3.1 SCV shall transmit to PER the active cab.

9.2.3.3.2 SCV shall detect if the train is in the light signal visibility area, as defined in 7.4.3.1.7.

9.2.3.3.3 When entering in light signal visibility area, SCV shall initialize a Signal Detection Request to PER, as defined in 7.8, if the following conditions are fulfilled:

- M_PER_RTSA_STATUS is AVAILABLE OR M_PER_RTSA_STATUS is ACTIVE,
- The active cab is oriented towards the target signal.

NOTE: M_PER_RTSA_STATUS is sent within packet 2 (see 13.1.1.3) as long as the state function is not FAILURE.

9.2.3.3.4 If M_PER_RTSA_STATUS is FAILURE OR M_PER_RTSA_STATUS is NOT AVAILABLE, while entering in light signal visibility area, then no Signal Detection Request shall be initialized.

NOTE: PER function RTSA being not available, no data will be transmitted to Train Protection and linking information will be applied by Train Protection at the passing of the VIP.

9.2.3.3.5 If the target light signal has changed due to rerouting, while the Signal Detection Request being active, then SCV shall cancel the Signal Detection Request.

9.2.3.3.5.1 To cancel a Signal Detection Request, SCV shall send a new Signal Detection Request with Q_SDRINIT == 0 as defined in 7.8.

9.2.3.3.6 SCV shall consider the Signal Detection Response Information only after proceeding a filter process, as defined hereafter.

9.2.3.3.7 The Figure 31 presents the process to filter signal aspect information provided by Signal Detection Response.

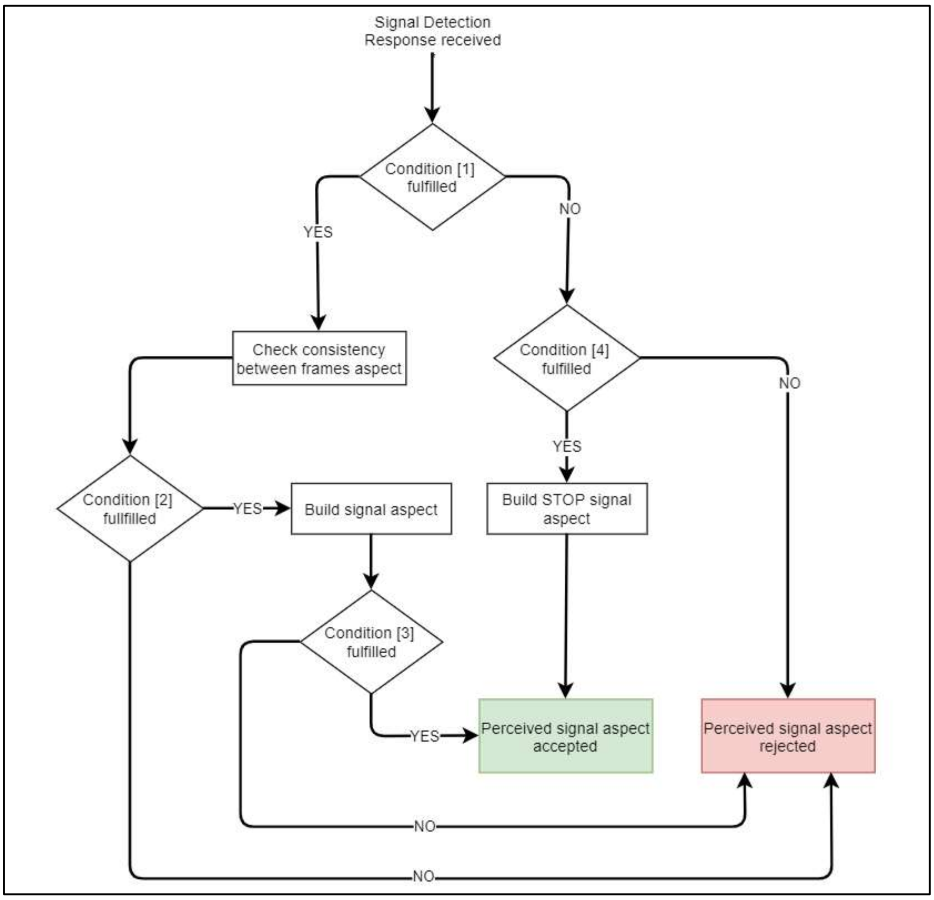

Figure 31: Schematic representation of the filtering of received information

9.2.3.3.7.1 NOTE 1: The function "check consistency between frames aspect" is defined in 9.2.3.3.9

9.2.3.3.7.2 NOTE 2: The function "build signal aspect" is defined in 9.2.3.3.10.

9.2.3.3.7.3 NOTE 3: The function "build STOP signal aspect" is defined in 9.2.3.3.11.

9.2.3.3.8 The Table 5 presents the conditions of acceptance consigned in Figure 31:

Condition ID	Content of the conditions
[1]	Each signal frame has a detected frame aspect. <=> no atomic frame aspect set to "not detected".
[2]	Frames aspects are consistent to each other as defined in 9.2.3.3.9
[3]	This signal aspect is stored in the VIP as a possible signal aspect. NOTE: it is the responsibility of the Digital Map to provide the invariants of trackside assets. If PER detects a signal aspect that is not contained in the VIP, then this is to be considered as a PER failure.
[4]	There is at least one frame aspect set to STOP/DANGER, as defined in [9]§Eu.SAT.209 or [9]§Eu.SAT.210.

Table 5: Conditions of acceptance filter

9.2.3.3.9 When condition 1 in Table 5 is fulfilled, then SCV shall check the consistency between the frame aspects as described below:

9.2.3.3.9.1 There is consistency between frame aspects if, for each byte of the signal vector, one to several frame aspects provide the same values whereas others are set to "intended dark" or "not equipped".

9.2.3.3.9.2 The example below illustrates two frame aspects inconsistent with each other.

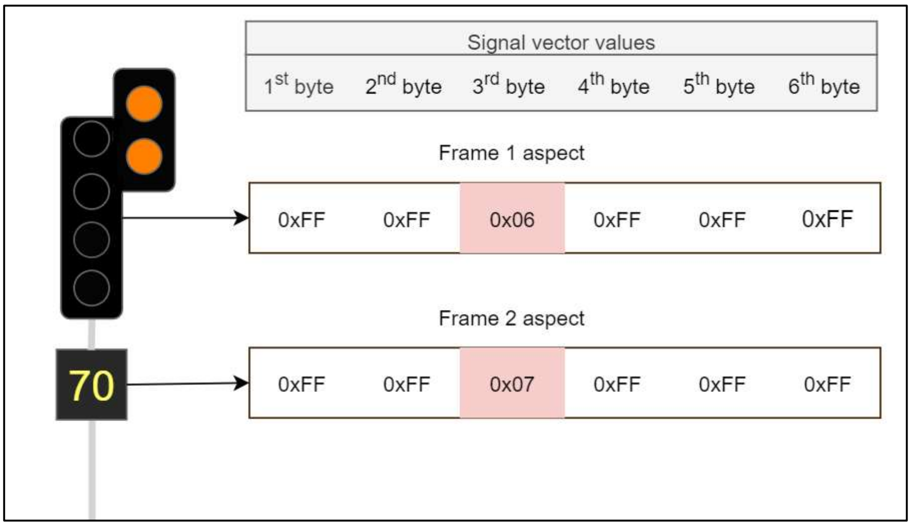

Figure 32: Example of frame aspects inconsistent with each other

On these signal frames aspects contained in a signal detection response,

- The signal vector of the signal frame 1 is consistent because it is a possible aspect of this signal frame.
- The signal vector of the signal frame 2 is consistent because it is a possible aspect of this signal frame.

However, the frame 1 aspect and the frame 2 aspect are not consistent with each other.

Indeed, the third bytes of the signal vector of each signal frame are not "commanded to dark" and provide a different information:

The 3rd byte of the signal frame 1 indicates "speed indicator 60 km/h" whereas the 3rd byte of the signal frame 2 indicates "speed indicator 70 km/h".

9.2.3.3.9.3 The example below illustrates two signal frames consistent with each other.

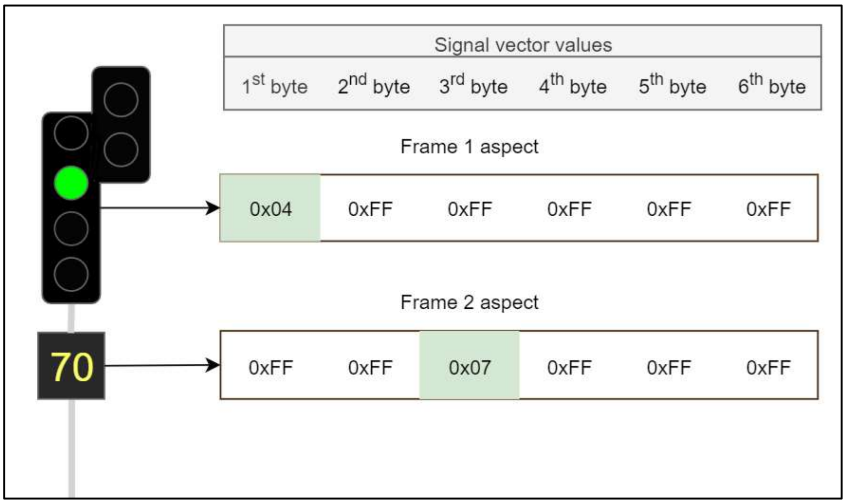

Figure 33: Example of frame aspects consistent with each other

On these frame aspects contained in a signal detection response,

- The signal vector of the signal frame 1 is consistent because it is a possible aspect of this signal frame.
- The signal vector of the signal frame 2 is consistent because it is a possible aspect of this signal frame.

Moreover, frame 1 aspect and the frame 2 aspect are consistent with each other.

Indeed, there is no byte presenting two different aspects.

9.2.3.3.10 When condition 2 in Table 5 is fulfilled, then SCV shall build the Perceived Signal Aspect gathering signal frames aspects: For each byte, aspect is set to (“intended dark/not equipped”) unless one aspect is set in a frame aspect.

9.2.3.3.10.1 The figure below shows an example of how to build a Perceived Signal Aspect thanks to frame aspects.

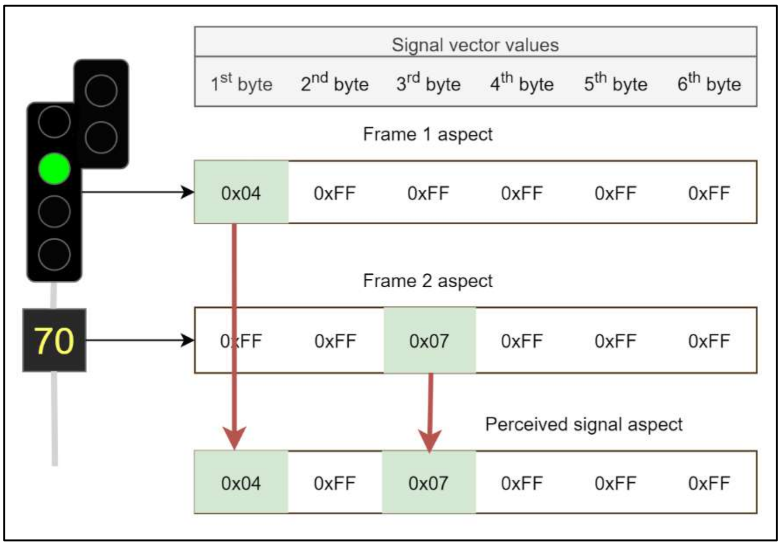

Figure 34: Example of the function “build perceived signal aspect”

9.2.3.3.11 When condition 3 in Table 5 is fulfilled, then SCV shall associate a level of confidence M_PERCEIVED_CONFIDENCE with the Perceived Signal Aspect.

9.2.3.3.11.1 M_PERCEIVED_CONFIDENCE == 1 if all the associated frame aspects received from PER have their M_DETECTION_CONFIDENCE == 1.

9.2.3.3.11.2 M_PERCEIVED_CONFIDENCE == 0 if at least one associated frame aspect received from PER have its M_DETECTION_CONFIDENCE == 0.

9.2.3.3.12 When condition 4 in Table 5 is fulfilled, then SCV shall build the Perceived Signal Aspect associated to STOP/Danger aspect. This is the following Signal Vector:

Signal vector values					
1st byte	2nd byte	3rd byte	4th byte	5th byte	6th byte
perceived signal aspect					
0x01	0xFF	0xFF	0xFF	0xFF	0xFF

Figure 35: STOP aspect Signal Vector

9.2.3.4 Compare Expected Signal Aspect and Perceived Signal Aspect

9.2.3.4.1 If Q_ACQUIRE == 1, then SCV shall acquire the Perceived Signal Aspect as defined in 9.2.3.3, and the Expected Signal Aspect as defined in 9.2.3.2.

9.2.3.4.2 If Q_ACQUIRE == 1, then SCV shall check the consistency between the Expected Signal Aspect and the Perceived Signal Aspect at a cycle time that shall be defined by further studies.

9.2.3.4.2.1 There is consistency between Expected Signal Aspect and Perceived Signal Aspect if and only if their signal vectors are equal.

9.2.3.4.2.2 The example below shows an Expected Signal Aspect and a Perceived Signal Aspect that are consistent with each other.

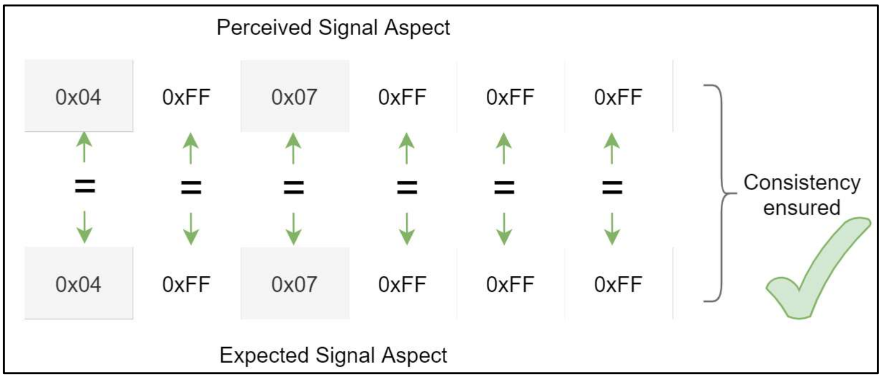

Figure 36: Perceived and Expected Signal Aspects consistent with each other

9.2.3.4.2.3 The example below shows an Expected Signal Aspect and a Perceived Signal Aspect discrepancy.

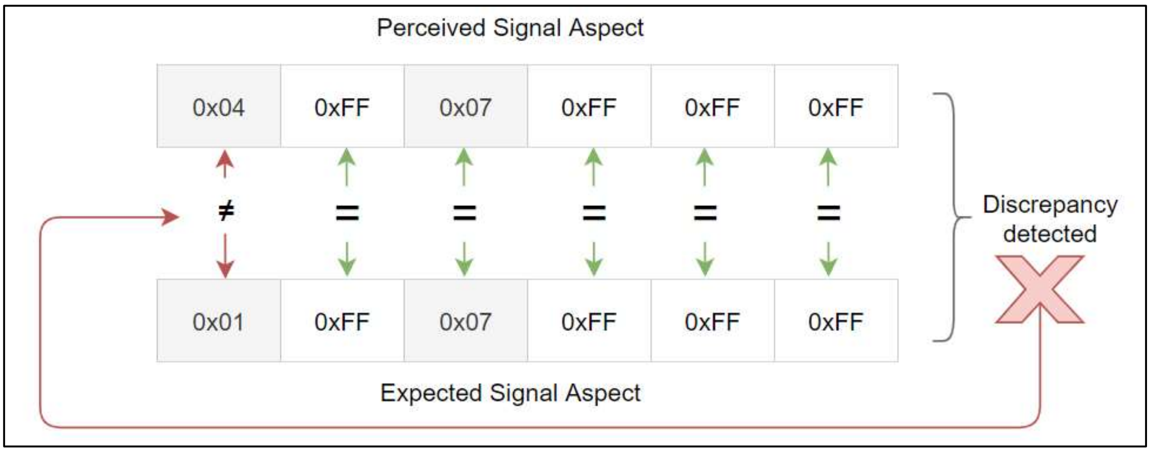

Figure 37: Discrepancy detected.

9.2.3.5 Assemble Target Signal Aspect

9.2.3.5.1 If Q_ACQUIRE == 0, then the Perceived Signal Aspect is the Target Signal Aspect.

9.2.3.5.2 If Q_ACQUIRE == 1, and the Expected Signal Aspect and the Perceived Signal Aspect are equal, then they form the Target Signal Aspect.

9.2.3.5.3 M_TARGET_CONFIDENCE is the confidence level of the Target Signal Aspect build from the Expected Signal Aspect and the Perceived Signal Aspect.

RATIONALE: M_TARGET_CONFIDENCE could enhance the overall safety integrity of SCV by combining information coming from two different sources: PER and OE. Further studies are required to define M_TARGET_CONFIDENCE.

9.2.3.5.4 If Q_ACQUIRE == 0, then M_TARGET_CONFIDENCE is M_PERCEIVED_CONFIDENCE

9.2.3.5.5 Expected Signal Aspect from REP, and Perceived Signal Aspect build by the function *Acquire Perceived Signal Aspect* are timestamped.

9.2.3.5.6 Further studies must define the time validity of both Expected Signal Aspect and Perceived Signal Aspect to build the Target Signal Aspect.

9.2.3.5.7 If Q_ACQUIRE == 1, and the Expected Signal Aspect and the Perceived Signal Aspect are not equal, then no Target Signal Aspect shall be build.

9.2.3.5.8 If Q_ACQUIRE == 1, then the value of M_TARGET_CONFIDENCE shall be 0 if the Target Signal Aspect is non safe.

9.2.3.5.9 If Q_ACQUIRE == 1, then the value of M_TARGET_CONFIDENCE shall be 1 if the Target Signal Aspect is safe.

9.2.3.5.10 How to define the value of M_TARGET_CONFIDENCE, build from M_EXPECTED_CONFIDENCE and M_PERCEIVED_CONFIDENCE must be dealt in further projects.

9.2.3.6 Flowcharts of the function "Acquire Target Signal Aspect"

9.2.3.6.1 The figure below presents the flowchart of the function Acquire Target Signal Aspect if Q_ACQUIRE == 0

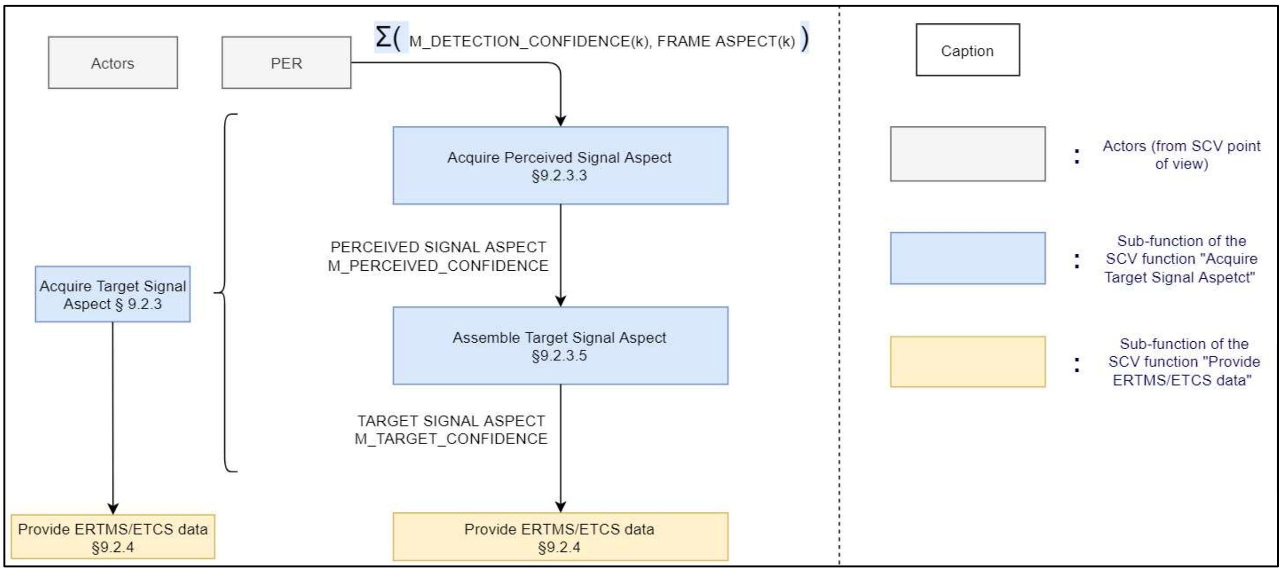

Figure 38: "Acquire Target Signal Aspect" if Q_ACQUIRE == 0

9.2.3.6.2 The figure below presents the flowchart of the function Acquire Target Signal Aspect if Q_ACQUIRE == 1

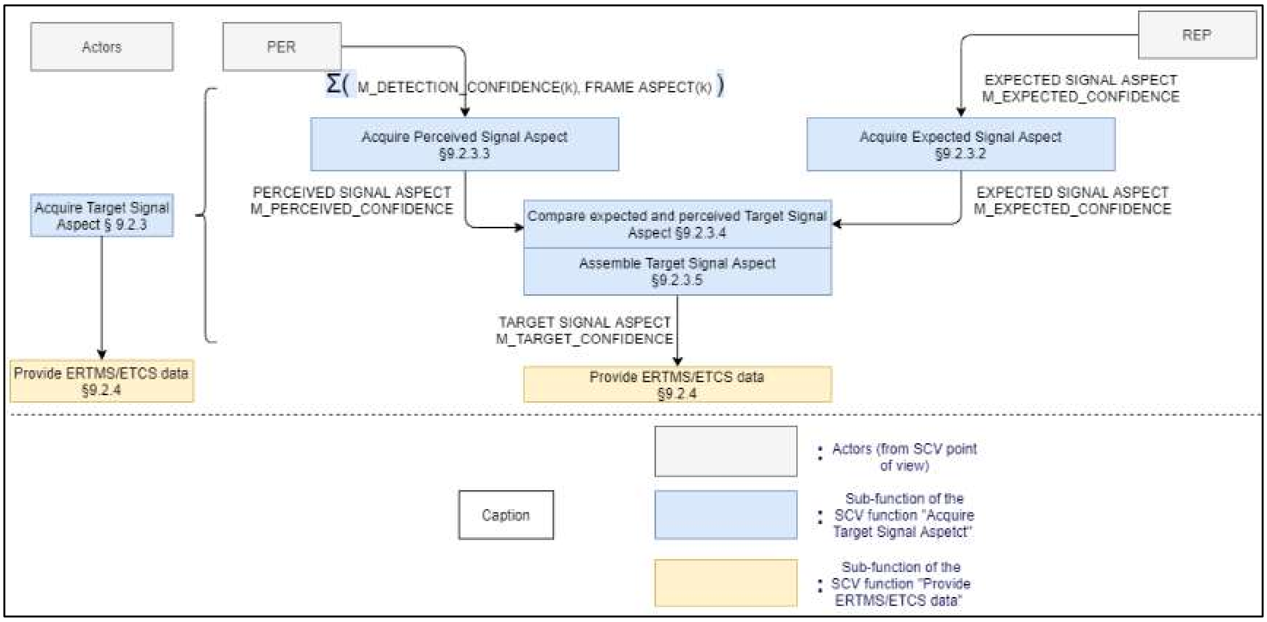

Figure 39: "Acquire Target Signal Aspect" if Q_ACQUIRE == 1

9.2.3.7 Stop the requests when passing the virtual information point

9.2.3.7.1 When Crossed VIP Message (see 11.4) is acquired, if Q_SDRINIT == 1, then SCV shall stop the signal detection request and set Q_SDRINIT == 0.

9.2.3.7.2 When Crossed VIP Message (see 11.4) is acquired, if Q_ESARINIT == 1, then SCV shall stop the signal detection request and set Q_ESARINIT == 0.

9.2.4 Provide ERTMS/ETCS data

9.2.4.1 Generic Requirements

9.2.4.1.1 SCV shall detect if the train is in an infill area, as defined in 7.4.3.1.6.

9.2.4.1.2 SCV shall acquire the active cab provided by Train Protection.

9.2.4.2 Provide infill ETCS information

9.2.4.2.1 If the train is in an infill area, and the level of confidence of the target signal aspect is M_TARGET_CONFIDENCE == 1, then SCV shall compute and send a Virtual ETCS Message to Train Protection.

9.2.4.2.2 To compute the virtual ETCS message, SCV shall select the virtual ETCS telegrams of the VIP following these conditions:

- The virtual ETCS telegram is a telegram associated with a signal aspect, AND
- Q_INFILL = 1, AND
- The associated signal aspect is the target signal aspect returned by the logical function "acquire target signal aspect".

9.2.4.2.3 Then, SCV shall order the ETCS data of each selected virtual ETCS telegram, within the virtual ETCS message, based on N_PIG and N_TOTAL values.

9.2.4.2.4 If the train is in an infill area, and the level of confidence of the target signal aspect is M_TARGET_CONFIDENCE == 0, and its aspect is a STOP aspect, then SCV shall compute and send a Virtual ETCS Message to Train Protection.

9.2.4.2.4.1 NOTE1: This is to handle unexpected STOP aspect.

9.2.4.2.4.2 NOTE2: In [9], the STOP aspect is referring to the values [0x01] and [0x21] of the byte the signal vector associated with the basic aspect type.

9.2.4.2.5 If the train is in an infill area, and the level of confidence of the target signal aspect is M_TARGET_CONFIDENCE == 0, and its aspect is not a STOP aspect, then SCV shall not send a Virtual ETCS Message to Train Protection.

9.2.4.2.6 The T_DATA of the Virtual ETCS Message shall be the Timestamp of the PER_SCV_SIGNAL_DETECTION Message which contained the Signal Detection Response which enabled SCV to compute the target signal aspect.

9.2.4.2.6.1 NOTE: This timestamp is defined by the function "Acquire target signal aspect".

9.2.4.2.7 The figure below shows an example of the function "provide infill information".

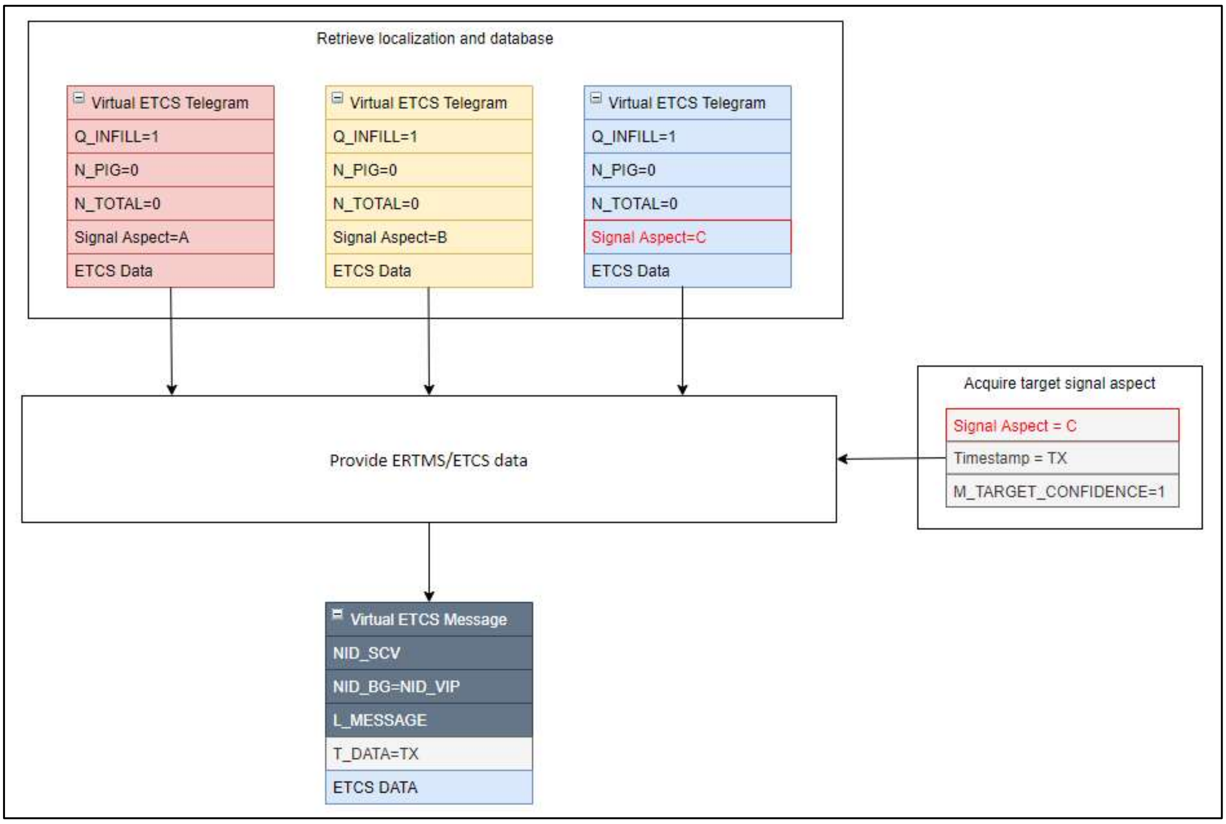

Figure 40: Example of the function "provide ETCS infill information"

- In the figure above, the SCV function "Retrieve localization and database" retrieves three infill Virtual ETCS Telegrams associated to the three possible signal aspects.
- In the figure above, each ETCS Data of each Virtual ETCS Telegram shall be sent at the first position (N_PIG=0)
- In the figure above, there is only one set of data to be sent in the Virtual ETCS Message (N_TOTAL=0).
- In the figure above, the function "Acquire target signal aspect" has acquired a target signal aspect "C", which is safe (M_TARGET_CONFIDENCE=1).
- Then, if the train is in an infill area, the function "Provide ETCS Information" gets the ETCS Data of the Virtual ETCS telegram associated with this target signal aspect.
- In the figure above, the timestamp to be used in the Virtual ETCS Message is the timestamp of the target signal aspect provided by the function "acquire target signal aspect".

9.2.4.3 Provide non-infill ETCS information.

9.2.4.3.1 When Crossed VIP Message (see 11.4) is acquired, then SCV shall send to Train Protection the Virtual ETCS Message containing non-infill information.

9.2.4.3.2 The target signal aspect to be used to compute the Virtual ETCS Message is the last safe signal aspect detected when the train was in the signal visibility area.

9.2.4.3.3 To compute the virtual ETCS message, SCV shall select the virtual ETCS telegrams of the VIP following one of the following conditions:

- The virtual ETCS telegram is a fixed ETCS telegram, OR
- The virtual ETCS telegram is a telegram associated with a target signal aspect AND Q_INFILL=0 AND the associated signal aspect is the target signal aspect returned by the logical function “acquire target signal aspect”.

9.2.4.3.4 Then, SCV shall order the ETCS data of each selected virtual ETCS telegram within the virtual ETCS message, based on N_PIG and N_TOTAL values.

9.2.4.3.5 Assumption: If no safe target signal aspect has been provided by the SCV function “Acquire target signal aspect”, then SCV shall not send a Virtual ETCS Message to Train Protection.

9.2.4.3.5.1 NOTE: This is the scope of Train Protection to apply linking reaction as defined in [1] §3.16.2.3 a). No detection of signal aspect shall be considered as a linking consistency problem.

3.16.2.3 Linking Consistency

3.16.2.3.1 If linking information is used the on-board shall react according to the linking reaction information in the following cases:

a) If the location reference of the expected balise group is found in rear of the expectation window

b) If the location reference of the expected balise group is not found inside the expectation window (i.e. the end of the expectation window has been reached without having found the expected balise group)

c) If inside the expectation window of the expected balise group another announced balise group, expected later, is found.

Figure 41: Extract of Subset 026, chapter “Linking Consistency”

9.2.4.3.6 The T_DATA shall be the UTC Time when Localization detected that the train has crossed the VIP.

9.2.4.3.6.1 NOTE: This timestamp is provided by the Crossed VIP Message, as defined in 11.4.1.1.2, to be used for reference location by Train Protection.

9.2.4.3.7 The figure below shows an example of the function “provide non-infill information”.

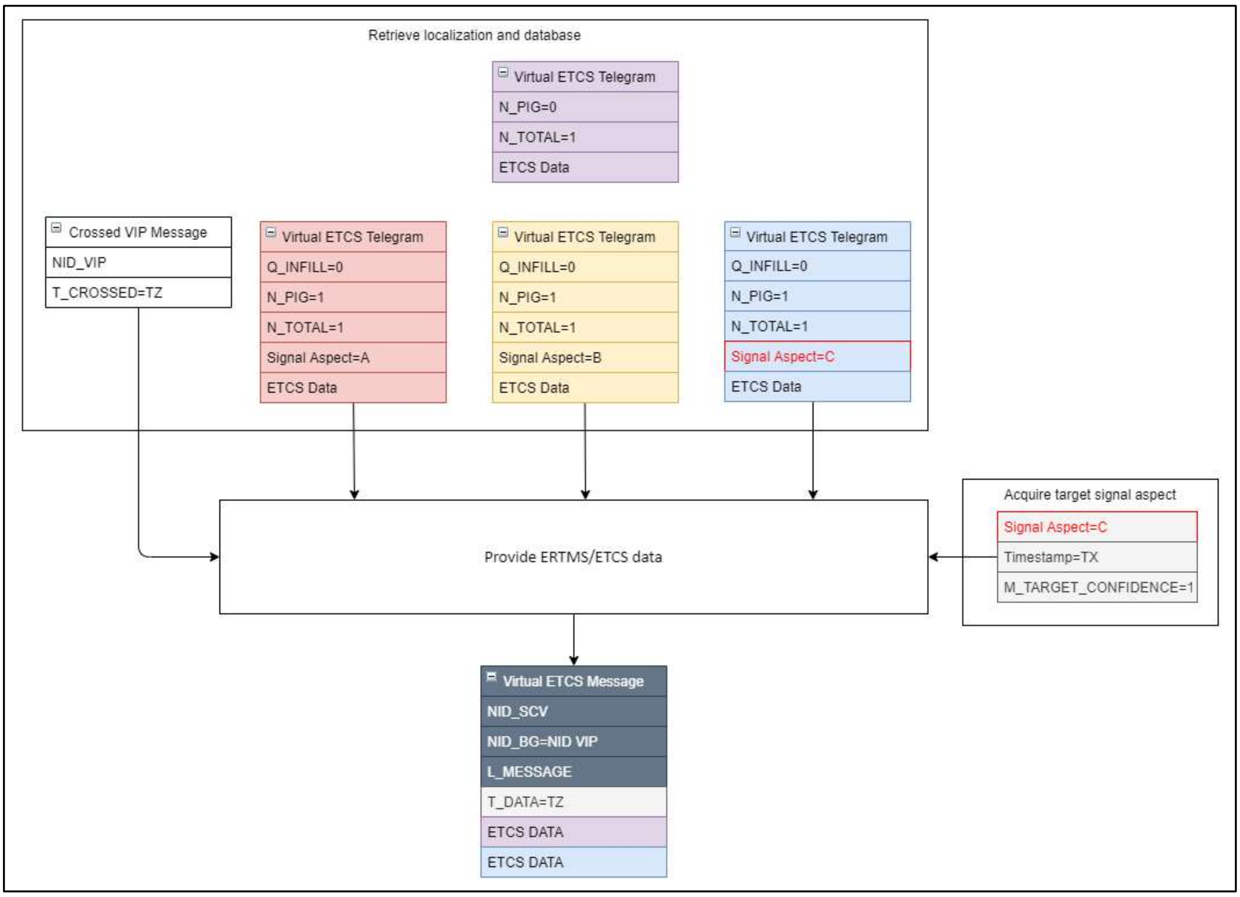

Figure 42: Example of the function "provide non-infill information"

- In the figure above, the SCV function "Retrieve localization and database" retrieves one static Virtual ETCS Telegram to be sent at the first position (N_PIG=0), and three non-infill Virtual ETCS Telegrams associated to three possible signal aspects to be sent at 2nd position (N_PIG=1).
- In the figure above, the SCV function "Acquire target signal aspect" has acquired a target signal aspect "C", which is safe (M_TARGET_CONFIDENCE=1). Moreover, the target signal aspect is still valid.
- In the figure above, the ETCS Data coming from the static Virtual ETCS Telegram is placed at the first position in the Virtual ETCS Message because it is associated with N_PIG=0.
- In the figure above, the ETCS Data coming from the Virtual ETCS Telegram associated with the acquired target signal aspect is placed at the 2nd position in the Virtual ETCS Message because its associated N_PIG=1.
- In the figure above, the timestamp of the data is the timestamp when the VIP was crossed (T_DATA=TZ).

9.3 SCV State Machine

9.3.1 No Power (NP)

9.3.1.1.1 SCV shall remain in NP state when it is switched off.

9.3.1.1.2 When it is in NP State, the SCV has no responsibility for train operation.

9.3.2 Not Available (NA)

9.3.2.1.1 When it is in NA State, the SCV is waiting REP, Localization and PER initialization.

9.3.3 Operational (OP)

9.3.3.1.1 When it is in OP state, SCV provides Train Protection with ETCS infill and non-infill information:

- based on the current location, data coming from the Digital Map, and using information provided by PER and REP associated to a signal aspect for virtual ETCS areas with signal detection,
- based on the current location and data coming from the Digital Map, for virtual ETCS areas without signal detection,

9.3.4 Failure (FA)

9.3.4.1.1 SCV shall enter in FA state in case of a fault which does not allow performing the SCV functions.

9.3.5 Transition between states

9.3.5.1.1 The transition table is defined below:

NP	<5 -p1-	<5t -p1-	<5 -p1-
1> -p1-	**AV**	<3 -p3-	
	2> -p3-	**OP**	
	4> -p2-	4> -p2-	**FA**

Table 6: Transition table (SCV)

9.3.5.1.2 The conditions transition table are defined below:

Cd Id	Content of the conditions
[1]	SCV is powered on.
[2]	REP is [OP], AND SCV has successfully subscribed the geometry layer to REP, AND SCV has successfully subscribed the signalling layer to REP, AND Localization is [OP], AND Train Protection has provided an active cab,
[3]	OR REP leaves OP state, OR cab is open, OR Localization leaves OP state.
[4]	SCV detects a fault which does not allow performing SCV functions.
[5]	SCV is powered off.

Table 7: Transition conditions table (SCV)

9.3.5.1.3 NOTE 1: Assumption: LZ is considered in [OP] if LZ provides SCV with NAV_INFO messages.

10 SIGNALLING LIBRARY

10.1.1.1.1 The VIPs are stored in a layer of the topology segment called Signalling Profile.

10.1.1.1.2 The Signalling Profile is described in [10].

10.1.1.1.3 The Signalling library is the library of the Signalling Profile.

10.1.1.1.4 The Signalling library is composed of Virtual Information Points.

10.1.1.1.5 The figure below presents this signalling library:

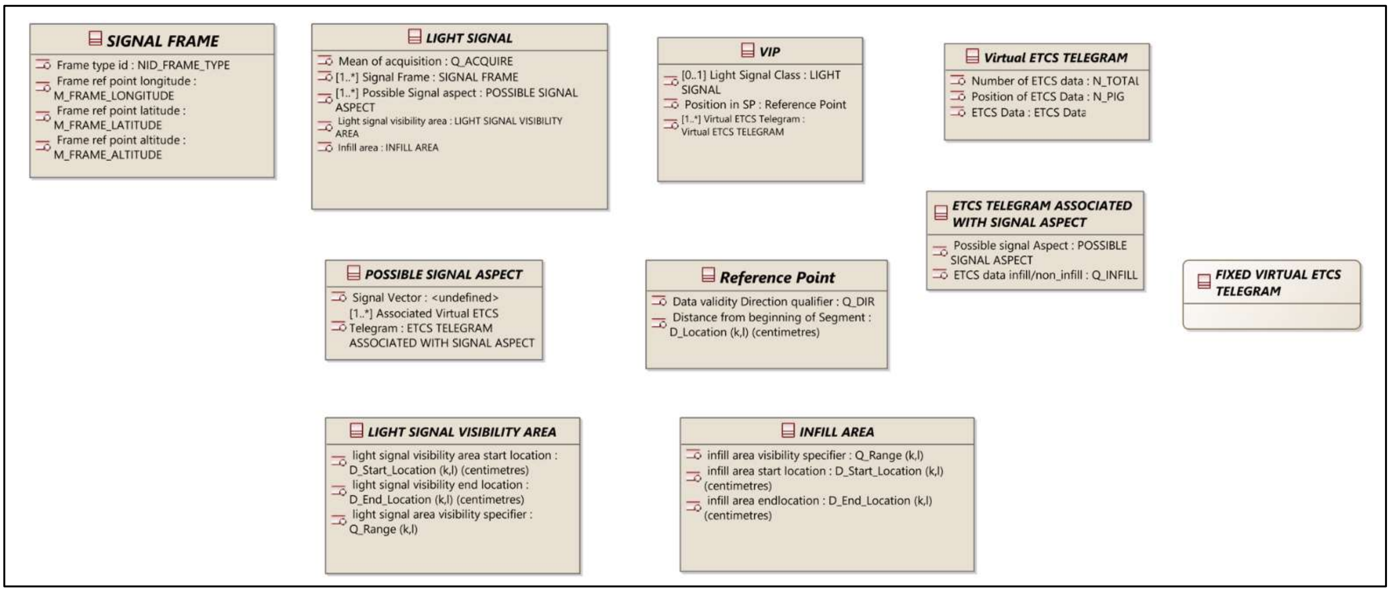

Figure 43: Signalling Profile data

11 EXPORTED CONSTRAINTS

11.1 Data Preparation

11.1.1 Exported Constraints on Signalling Layer

11.1.1.1 GNSS latitude coordinate of a signal frame M_ FRAME_LATITUDE

11.1.1.1.1 The accuracy of the GNSS latitude position coordinate of a signal frame to be detected shall be less than or equal to 1 m.

11.1.1.1.2 The resolution of the GNSS latitude position coordinate of a signal frame to be detected shall be in degrees (° x 10-7).

11.1.1.2 GNSS longitude coordinate of a signal frame M_FRAME_LONGITUDE

11.1.1.2.1 The accuracy of the GNSS longitude position coordinate of a signal frame to be detected shall be less than or equal to 1 m.

11.1.1.2.2 The resolution of the GNSS longitude position coordinate of a signal frame to be detected shall be in degrees (° x 10-7).

11.1.1.3 GNSS ellipsoid altitude coordinate of a signal frame M_ FRAME_ALTITUDE

11.1.1.3.1 The accuracy of the GNSS ellipsoid altitude position coordinate of a signal frame to be detected shall be less than or equal to 1 m.

11.1.1.3.2 The resolution of the GNSS ellipsoid altitude coordinate of a signal frame to be detected shall be 0.1 m.

11.1.1.4 Vertical height of the target light signal

11.1.1.4.1 NOTE: The vertical height of the signal frame to be detected corresponds to the distance from the top of the rails to the high point of the signal frame, as defined in Figure 44 and Figure 45.

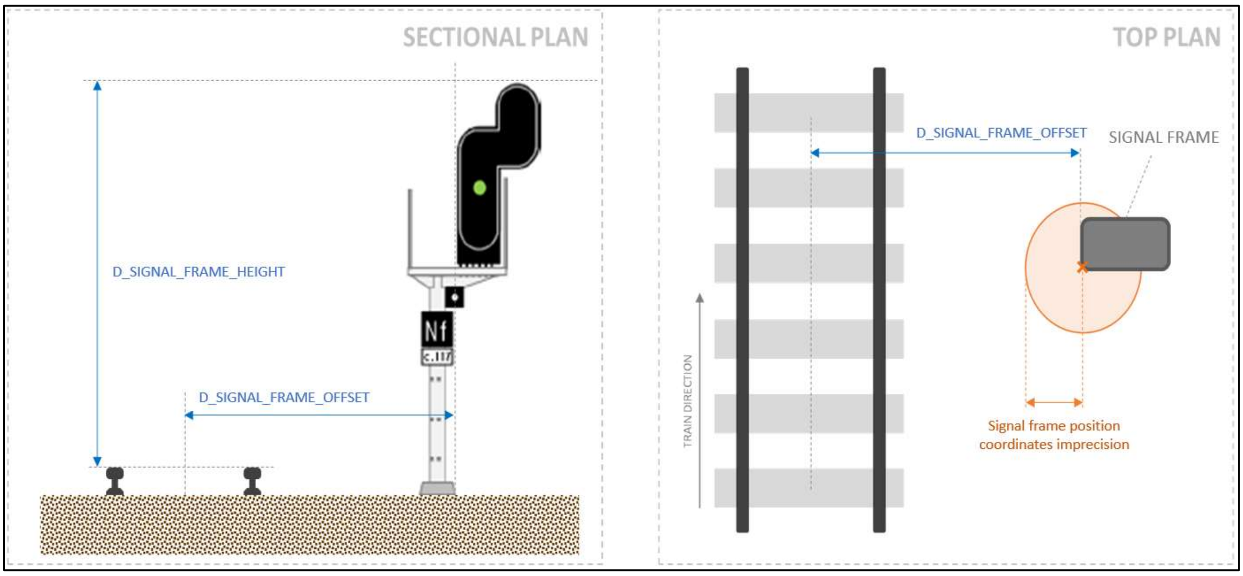

Figure 44: Signal frame height and signal frame offset (right position)

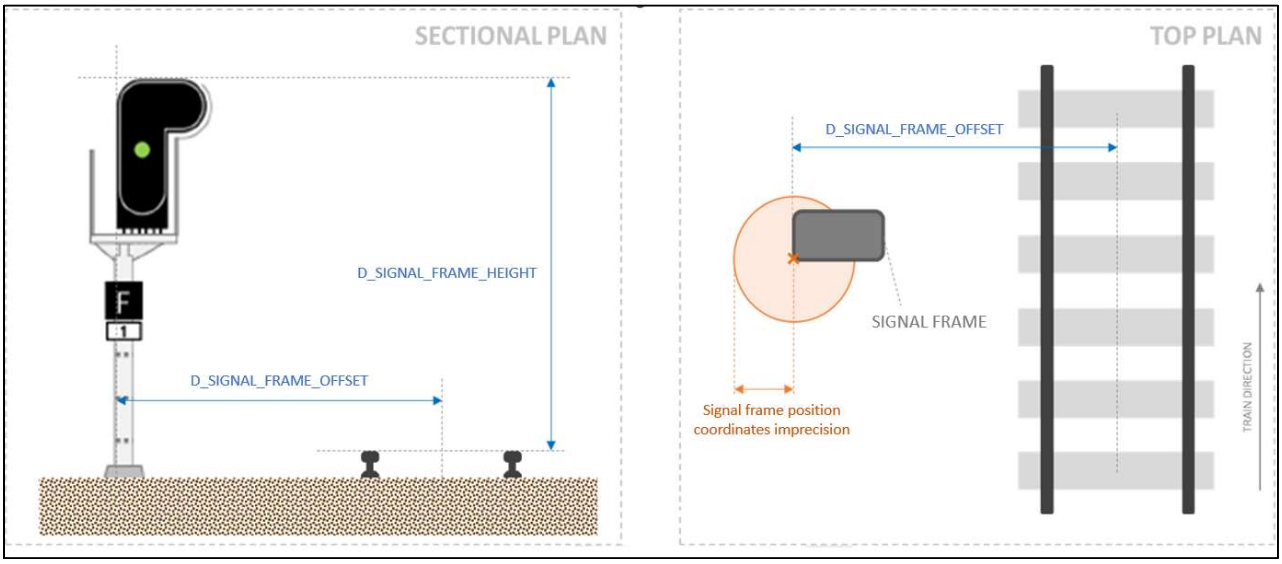

Figure 45: Signal frame height and signal frame offset (left position)

11.1.1.4.2 The accuracy of the vertical height of the signal frame to be detected shall be less than or equal to 0.1 m.

11.1.1.4.3 The resolution of the vertical height of the signal frame to be detected shall be 0.01 m.

11.1.1.4.4 The height between the altitude of the first vertex and the altitude of the signal frame reference point shall be strictly equal to the vertical height of the signal frame.

11.1.1.5 Transverse offset of the target light signal

11.1.1.5.1 NOTE: The transverse offset of the signal frame to be detected corresponds to the distance from the left point of the signal frame to the centre of the rails of the associated track, as defined in Figure 44 and Figure 45.

11.1.1.5.2 The accuracy of the transverse offset of the signal frame to be detected shall be less than or equal to 0.1 m.

11.1.1.5.3 The resolution of the transverse offset of the signal frame to be detected shall be 0.01 m.

11.1.1.5.4 The horizontal distance between the position of the first vertex and the position of the signal frame reference point shall be strictly equal to the transverse offset signal frame to be detected.

11.1.1.6 Exported Constraints on ETCS application engineering

11.1.1.6.1 Linking shall be used between VIP.

11.1.1.6.1.1 Rationale: linking enables:

- Train Protection to apply linking reaction if no signal aspect is sent by SCV,
- Train Protection to accept ERTMS/ETCS infill Information,
- Train Protection to provide REP with linking information to map REP with the route.

11.1.2 Exported Constraints on Geometry Layer

11.1.2.1 Introduction

11.1.2.1.1 If a VIP is associated with a light signal, then the following exported constraints shall apply on the geometry profile.

11.1.2.1.2 These exported constraints shall apply from 200 m in rear of the target light signal position to the target light signal.

11.1.2.2 Track Vertices location on the geometry layer constraints

11.1.2.2.1 The linear distance between two successive vertices shall be less than or equal to 20 m.

11.1.2.2.2 The vertices shall cover the entire rail approach area, from the train to the target light signal over a linear distance of 200 m.

11.1.2.2.3 A vertex shall be positioned at the intersection between the centre of the rail line and the orthogonal projection of the target light signal position. This Track Vertex is named Light Signal Vertex.

11.1.2.2.4 The number of vertices depends on the precision required for the description of the rail approach information.

11.1.2.2.4.1 NOTE: The higher the number of vertices, the greater the precision of the description of the rail approach information. Conversely, fewer the number of vertices, the less the precision of the description of the rail approach information is important.

11.1.2.3 GNSS latitude coordinate of the vertices M_CMMAP_LATITUDE (k)

11.1.2.3.1 The accuracy of the GNSS latitude position coordinate of the vertex (k) shall be less than or equal to 1 m.

11.1.2.3.2 The resolution of the GNSS latitude position coordinate of the vertex (k) shall be in degrees (° x 10-7).

11.1.2.4 GNSS longitude coordinate of the vertices M_CMMAP_LONGITUDE (k)

11.1.2.4.1 The accuracy of the GNSS longitude position coordinate of the vertex (k) shall be less than or equal to 1 m.

11.1.2.4.2 The resolution of the GNSS longitude position coordinate of the vertex (k) shall be in degrees (° x 10-7).

11.1.2.5 GNSS ellipsoid altitude coordinate of the vertices M_CMMAP_ALTITUDE (k)

11.1.2.5.1 The accuracy of the GNSS ellipsoid altitude position coordinate of the vertex (k) shall be less than or equal to 1 m.

11.1.2.5.2 The resolution of the GNSS ellipsoid altitude position coordinate of the vertex (k) shall be 0.1 m.

11.2 OPERATIONAL EXECUTION

11.2.1.1.1 When OE has provided REP with a JP, then OE shall send to REP the signal aspects of all light signals in the route of the JP.

11.2.1.1.2 OE shall send for each light signal in the route of the JP, it's signal aspect in the signal vector format.

11.2.1.1.3 For each signal vector, OE shall provide REP the identification of the light signal for which the signal vector addresses it's aspect.

11.2.1.1.4 For each signal vector, OE shall provide the M_EXPECTED_CONFIDENCE value.

11.2.1.1.5 OE shall send the signal vectors at a cycle time value that must be determined in further projects.

11.2.1.1.6 These exported constraints must be further studied in the context of OE specification and OE/REP communication principles.

11.2.1.1.6.1 NOTE: This topic is also of interest for the use of C-DAS connected to REP, so that C-DAS takes into account the aspect of the signals.

11.3 REP

11.3.1 Data

11.3.1.1.1 REP shall provide SCV with Signalling Profile Information.

11.3.1.1.2 REP shall provide SCV with Geometry Profile Information.

11.3.2 Expected Signal Aspect Response

11.3.2.1.1 When REP receives an Expected Signal Aspect Request from SCV (Q_ESARINIT == 1), associated with the N_VIP, then REP shall provide the Expected Signal Aspect Response as defined in 7.11.1.1.2.

11.3.2.1.2 When REP receives an Expected Signal Aspect Request from SCV (Q_ESARINIT == 1), associated with the N_VIP, then REP shall provide the Expected Signal Response to SCV every 100 ms.

11.3.2.1.3 When REP provides an Expected Aspect Response to SCV, and Q_ESARINIT value switches from 1 to 0, then REP shall stop sending the Expected Signal Aspect Response to SCV.

11.4 LOCALIZATION

11.4.1 Localization functional Requirements

11.4.1.1.1 When crossing a VIP, LZ shall send to SCV a Crossed VIP Message.

11.4.1.1.2 The Crossed VIP Message shall contain:

a) The ID of the crossed VIP.
b) The UTC Time when crossing has been detected.

11.4.1.1.3 In this concept, LZ is considered in state OP if LZ provides SCV with NAV_INFO messages.

11.4.2 Localization performance requirements

11.4.2.1 Train Navigation performance requirements

11.4.2.1.1 Localization shall guarantee the accuracy of the current latitude coordinates of each cabin of the train better than 5 meters.

11.4.2.1.2 Localization shall guarantee the accuracy of the current longitude coordinates of each cabin of the train better than 5 meters.

11.4.2.1.3 Localization shall guarantee the accuracy of the current ellipsoid altitude coordinates of each cabin of the train better than 5 meters.

11.4.2.1.4 Localization shall guarantee the accuracy of the train roll orientation on local tangential referential better than 0.3 degree.

11.4.2.1.5 Localization shall guarantee the accuracy of the train pitch orientation on local tangential referential better than 0.3 degree.

11.4.2.1.6 Localization shall guarantee the accuracy of the train heading orientation on local tangential referential better than 1 degree.

11.5 TRAIN PROTECTION

11.5.1 Linking Packet

11.5.1.1.1 To improve safety and security, Train Protection shall be informed if next Information Points are virtual or physical.

RATIONALE: The mechanism to consider a VIP or a physical information point as missed is different.

11.5.1.1.2 Thus, a hybrid linking packet shall be designed, and accepted by Train Protection to enable to link physical and or VIP to each other.

11.5.1.1.3 Further studies are required to determine the content of the packet, and the adaptation of functional requirements of Train Protection to consider “hybrid linking” and linking reaction.

11.5.2 Active cab

11.5.2.1.1 Train Protection shall provide to SCV the active cab.

12 OPEN POINTS

12.1 NON-INFILL MA OPEN POINTS

12.1.1 Statement

In physical ERTMS/ETCS Level 1 area, the infill MA is based on the track occupancy status of the route in advance of the target light signal, at the time when this infill MA is computed. Train Protection accepts this infill MA only its ERTMS/ETCS mode is FS/AD or LS (see [1] §3.8.4.6).

In the concept, the train is provided with infill MA(s) based on the track occupancy status of the route in advance of the target light signal **at the time when the associated signal aspect is detected.**

In physical ERTMS/ETCS Level 1 area, the train is provided with a non-infill MA when crossing the main signal balise group. This non-infill MA is based on the track occupancy status of the route in advance of the light signal, **at the time when the train crosses the main balise group.**

At this position, the target light signal may not be visible anymore. Thus, as defined in §9.2.4.3.2 , **the non-infill MA is not based on the target signal aspect when passing the BG** (as it would be in physical in ERTMS/ETCS Level 1)**, but on the last detected signal aspect,** before losing visibility of the target signal.

12.1.2 Consequences of this statement

12.1.2.1 Consequence 1: Section Timer topic

As a consequence, there is an open point about the time for which the MA sections are valid.

In physical ERTMS/ETCS Level 1, the time when starting the section timers is the time:

- When the train crosses the first balise of the balise group for non-infill MA (see [1]§3.8.4.2.1),
- When the train receives the infill MA provided by an euroloop (see [1]§ 3.8.4.6.5),
- Of the timestamp of the radio message of the infill MA provided by a RIU (see [1]§ 3.8.4.6.5).

Thus, section timers are started approximately at the time when associated ETCS information is computed by the trackside.

In the concept, section timers of non-infill MA are started at the time when Localization considers the VIP as crossed (see 9.2.4.3.6).

It shall be noticed that the time when the last safe signal aspect is detected by PER is earlier than the time when the VIP is crossed. Thus, unlike physical ERTMS/ETCS Level 1**, section timers are started later than the time when the information from trackside is provided by the target light signal**.

Thus, there is a subject about validity time of MA sections, especially if the train takes a long time to travel between the location where the last target signal aspect is detected and the location of the VIP.

12.1.2.2 Consequence 2: Hazardous situation if another train is located between the ego train front end and the target light signal

Moreover, the difference between physical Level 1 and our concept described in 12.1.1 could create the following hazardous situation:

- A train A is approaching the target light signal,
- The train A is in OS/SR mode,
- A train B is located between the train A front end and the target light signal.

If there is no train on the section in advance of the light signal, the target signal aspect could present a proceed aspect. The situation is described on the figure below:

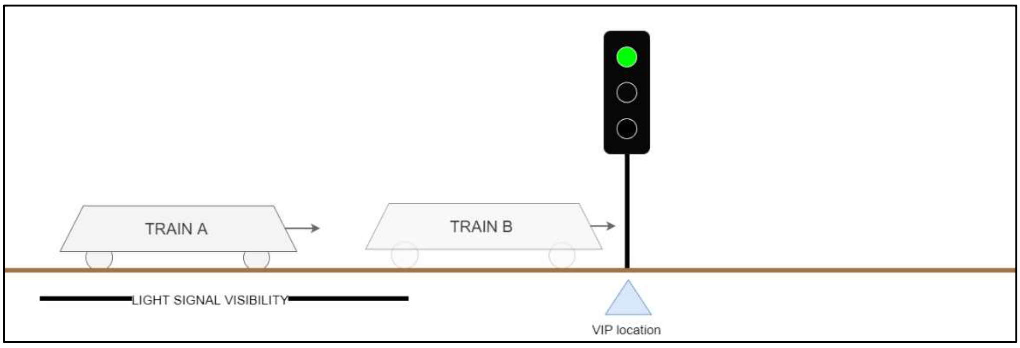

Figure 46: A train B between the train A and the target light signal

Then, the target light signal could present a STOP/permissive STOP aspect when the train B enters the section in advance of the signal.

If the train A has already left the cone of visibility of the target light signal when the target light signal switches from proceed to STOP/permissive STOP aspect, then the last detected signal aspect used to compute the non-infill MA is the proceed aspect. This situation is described below.

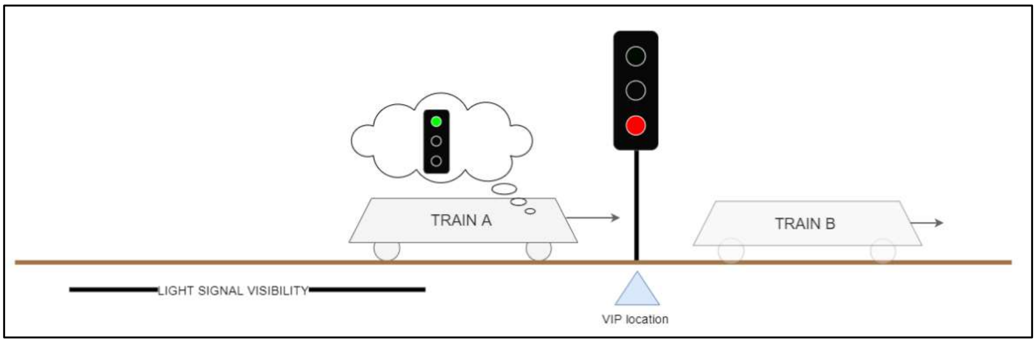

Figure 47: The target light signal switches its aspect whereas the train A has left its cone of visibility

Then, the train A will switch from OS/SR to FS mode when crossing the VIP location, whereas there is still a train B in advance of its position and the target light signal present a STOP/permissive STOP aspect.

To conclude, SCV cannot build a main MA based on the last detected signal aspect if the train is in OS/SR mode.

12.1.3 Solution proposal 1

12.1.3.1 Description the solution

The first solution could be to reduce the scope of SCV: SCV sends infill MA, but not non-infill MA anymore.

12.1.3.2 Impact on X2RAIL-4

If SCV sends only infill MA to Train Protection, then Train Protection won't be able to reach the FS mode. Indeed, infill MA are currently only accepted by Train Protection while in FS/LS mode (see [1]§3.8.4.6.2).

A constraint can be exported to Train Protection to enable the on-board to reach the FS mode if it was previously in SR/OS mode.

The constraint is the following: Train Protection should accept infill MA if the train is in OS/SR mode if there is no train between the train front end position and the target light signal.

Train Protection should also ask APM (GoA34) or the driver (GoA2) to ensure that there is no other train between the train front end and the target light signal.

The way to ask the driver or APM is an open topic to be studied in a further project.

12.1.4 Solution proposal 2

12.1.4.1 Description the solution

The second solution is to let SCV sending non-infill MA. In this case, SCV should have the following additional responsibilities:

- If Train Protection is in OS/SR mode then SCV should have the responsibility to provide non-infill MA only if there is no other train between the train front end and the target light signal location.
- SCV should compute the correct T_SECTIONTIMER(s) of the non-infill MA.

12.1.4.2 Impact on SCV and X2RAIL-4

In this proposal, Train Protection should provide SCV with its ERTMS/ETCS mode via C17.

SCV shall request PER or Train Protection if the track between the train front end and the target light signal location is free.

The way to ask PER or Train Protection is an open topic to be studied in a further project.

In this proposal, SCV could reduce the validity time of the non-infill MA sections, taking into account the time the train has taken to travel between the location where the last target signal aspect was detected and the location of the VIP.

12.2 TRAIN PROTECTION CANNOT SWITCH TO FS MODE

12.2.1 Problem statement

In [2]§7.9.4.1.5, it is written, concerning the path of the signalling profile and the geometry profile provided by REP to SCV, that "the path is limited to the length of the MA".

The objective of this clause is to consolidate within REP, the information of the JP with the MA to have a safe route, and for REP, to distribute to the on-board modules the data related to this route.

It should be noticed that, in our concept, the on-board starts in SR mode, so without MA. Consequently, the clause 7.9.4.1.5 prevents REP to provide SCV with the signalling profile and the geometry profile.

Thus, PER cannot detect any light signal, SCV cannot provide Train Protection with any MA and, the train remains in SR mode.

12.2.2 Solution proposal

It should be noticed that, when a train is powered on, its ERTMS/ETCS Train Position is still valid if no cold movement has been detected while it was powered off.

Thus, the solution could be, if Train Protection is not yet provided with an MA, to combine within REP, JP Information with Train Position Information, to have a path from the beginning of the JP to the next switch.

12.3 TEMPORARY AND UNEXPECTED SIGNALLING

Temporary and unexpected signalling is not in the scope of this concept and shall be defined by a further project.

12.4 OTHER OPEN POINTS:

Paragraph	Description
2.1.1.1.27	Operational rules and hazard analysis to be studied further.
6.1.1.1.10	FFFIS interfaces to be defined.
7.5.1.1.7	Studies on EULYNX project shall be performed to continue the standardization activity of the Signal Aspect Table [9].
7.8.1.1.9	European standardization of NID_FRAME_TYPE to be defined
7.9.1.1.7	Specifications of M_DETECTION_CONFIDENCE to be defined further.
7.11.1.1.4	Specifications of M_EXPECTED_CONFIDENCE to be defined further.
8.2.2.2.5	The balance between safety and operability for unexpected STOP detection to be defined further.
8.5.1.1.1	The state machine of PER shall be defined in a compatible way with all allocated functions.
9.2.3.4.2	The cycle time to check consistency between expected signal aspect and perceived signal aspect shall be defined.
9.2.3.5.3	Further studies are required to define M_TARGET_CONFIDENCE.
9.2.3.5.6	Further studies must define the time validity of both Expected Signal Aspect and Perceived Signal Aspect to build the Target Signal Aspect.
9.2.3.5.10	The way to define the value of M_TARGET_CONFIDENCE shall be studied by a further project.
11.2.1.1.5	OE shall send the signal vectors at a cycle time value that must be determined in a further project.

11.5.1.1.3	Further studies are required to determine the content of the packet, and the adaptation of functional requirements of Train Protection to consider “hybrid linking” and linking reaction.
13.1.2.1.1	Interface C26 to be defined in X2RAIL4.
13.1.3	Interfaces C20/C62 to be defined in X2RAIL4.
13.1.4	Interface C17 to be defined by a further project.

Table 8: Open Points Table

13 APPENDICES

13.1 INTERFACES

13.1.1 Interface C39

13.1.1.1 C39 List of Packets

Packet Number	Packet Name	Source	Sink	Transmittting cycle [ms]	Data Class [Ref 1]
1	SCV_PER_SIGNAL_DETECTION_REQUEST	SCV	PER	-	Message data
2	PER_SCV_SIGNAL_DETECTION	PER	SCV	50	Process data
3	SCV_PER_ACTIVE_CAB	SCV	PER	-	Message data

Table 9: C39 Packet summary

13.1.1.1.1 The packets for which no transmitting cycle is defined in the above table are sent event-based.

13.1.1.2 Packet number 1: SCV_PER_SIGNAL_DETECTION_REQUEST

Packet Number		1		
Item	**Variable Name**	**Description**	**Date Type**	**Resolution/Formula**
0	Q_SDRINIT	Qualifier for resuming the initial states of the related signal detection request of the packet.	UINT8	**Value**: 0 = No initial states to be resumed, signal detection request to follow 1 = Empty signal detection request, initial states to be resumed
1	NID_C	If Q_SDRINIT = 0 Identity number of the country or region. Variable from SRS	UINT16	See [R2], §7.5.1.86 **Special Values**: 1024 - 65535 = spare
Signal frame properties				
2	M_FRAME_LATITUDE	[If Q_SDRINIT = 0] GNSS latitude coordinate (WGS84) of the target light signal frame to be detected	INT32	**Resolution**: ° x 10^{-7} **Special value**: (-2^{31}) – (-900000001) = spare 900000001 - $(2^{31}-2)$ = spare
3	M_FRAME_LONGITUDE	If Q_SDRINIT = 0] GNSS longitude coordinate (WGS84) of the target light signal frame to be detected.	INT32	**Resolution**: ° x 10^{-7} **Special value**: (-2^{31}) – (-1800000000) = spare 1800000001 - $(2^{31}-2)$ = spare
4	M_FRAME_ALTITUDE	[If Q_SDRINIT = 0] GNSS ellipsoid altitude coordinate (WGS84) of the target light signal frame to be detected.	INT32	**Resolution**: 0.1 m
5	NID_FRAME_TYPE	If Q_SDRINIT = 0] Identity number of the type of the signal frame to be detected.	UINT16	NOTE: Values are defined at project level.
Additional signal frame properties				
6	N_FRAME_ITER	[If Q_SDRINIT = 0] Number of additional frames to be detected	UINT8	**Special values:** 0 = no additional signal frame 4-255 = spare
7	M_FRAME_LATITUDE (n)	[If Q_SDRINIT = 0] GNSS latitude coordinate (WGS84) of the target light signal frame to be detected	INT32	**Resolution**: ° x 10^{-7} **Special value**: (-2^{31}) – (-900000001) = spare 900000001 - $(2^{31}-2)$ = spare

8	M_FRAME_LONGITUDE (n)	If Q_SDRINIT = 0] GNSS longitude coordinate (WGS84) of the target light signal frame to be detected.	INT32	**Resolution**: ° x 10^{-7} **Special value**: (-2^{31}) – (-1800000000) = spare 1800000001 - $(2^{31}-2)$ = spare
9	M_FRAME_ALTITUDE (n)	[If Q_SDRINIT = 0] GNSS ellipsoid altitude coordinate (WGS84) of the target light signal frame to be detected.	INT32	**Resolution**: 0.1 m
10	NID_FRAME_TYPE (n)	If Q_SDRINIT = 0] Identity number of the type of the signal frame to be detected.	UINT16	NOTE: Values are defined at project level.
Micro mapping Information				
11	N_CMMAP_ITER	[If Q_SDRINIT = 0] Number of track vertices for relevant area of interest.	UINT8	**Special values**: 0 = no micro-mapping information available
12	M_CMMAP_LATITUDE (k)	[If Q_SDRINIT = 0] Latitude (WGS84) of the track vertex (k) corresponding to the center of the track travelled by the train.	INT32	**Resolution**: ° x 10^{-7} **Special value**: (-2^{31}) – (-900000001) = spare 900000001 - $(2^{31}-2)$ = spare
13	M_CMMAP_LONGITUDE (k)	[If Q_SDRINIT = 0] Longitude (WGS84) of the track vertex (k) corresponding to the center of the track travelled by the train.	INT32	**Resolution**: ° x 10^{-7} **Special value**: (-2^{31}) – (-1800000000) = spare 1800000001 - $(2^{31}-2)$ = spare
14	M_CMMAP_ALTITUDE (k)	[If Q_SDRINIT = 0] Altitude (WGS84) of the track vertex (k) corresponding to the center of the track travelled by the train.	INT32	**Resolution**: 0.1 m

Table 10: Packet number 1: SCV_PER_Signal_Detection_Request

13.1.1.3 Packet number 2: PER_SCV_SIGNAL_DETECTION

Packet Number		***2***			
Item	**Variable Name**		**Description**	**Data Type**	**Resolution/Formula**
0	M_PER_RTSA_STATUS		PER status for RTSA function	UINT8	**Values:** 0 = Function available and ready for signal detection 1 = Function in signal detection 2 = Function failure 3 = Function not available 4 - 255 = spare
1	NID_C		[If M_PER_RTSA_STATUS== 1] Identity number of the country or region.	UINT16	See [1], §7.5.1.86 **Special Values**: 1024 - 65535 = spare
Frame aspect Information					
2	NID_FRAME_TYPE		[If M_PER_RTSA_STATUS== 1] Identity number of the type of the detected frame aspect.	UINT16	NOTE: Values are defined at project level.
3	M_DETECTION _CONFIDENCE		[If M_PER_RTSA_STATUS== 1] Confidence level of the detected frame aspect.	UINT8	**Values:** 0 = for non-safe information 1 = for safe information
	Byte	Eulynx Signal Vector			See [6]&EU.DK.255
4	1	M_BASIC_ASPECT_TYPE	[If M_PER_RTSA_STATUS== 1] Basic Aspect Type	BITSET8	See [9] Signal Aspect Table 2.1

5	2	M_EXTENSION_BASIC_ASPECT_TYPE	[If M_PER_RTSA_STATUS== 1] Extension of basic aspect type	BITSET8	See [9]Signal Aspect Table, §2.2
6	3	M_SPEED_INDICATOR	[If M_PER_RTSA_STATUS== 1] Speed indicator	BITSET8	See [9]Signal Aspect Table, §2.3
7	4	M_SPEED_INDICATOR_ ANNOUNCEMENTS	[If M_PER_RTSA_STATUS== 1] Speed indicator announcements	BITSET8	See [9]Signal Aspect Table, §2.4
8	5	M_DIRECTION_INDICATOR	[If M_PER_RTSA_STATUS== 1] Direction indicators	BITSET8	See [9] Signal Aspect Table, §2.5
9	6	M_DIRECTION_INDICATOR_ ANNOUNCEMENT	[If M_PER_RTSA_STATUS== 1] Direction indicator announcements	BITSET8	See [9] Signal Aspect Table, §2.6
Additional frame aspect information					
10	N_FRAME_ITER		[If M_PER_RTSA_STATUS== 1] Number of additional signal frames	UINT8	**Special values:** 0 = no additional signal frame 4-255 = spare
11	NID_FRAME_TYPE(k)		[If M_PER_RTSA_STATUS== 1] Identity number of the type of the detected frame aspect.	UINT16	NOTE: Values are defined at project level.
12	M_DETECTION _CONFIDENCE(k)		[If M_PER_RTSA_STATUS== 1] Confidence level of the detected frame(k) aspect.	UINT8	**Values:** 0 = to be use for operational use-cases. 1 = to be used for safety use-cases.
	Byte	Eulynx Signal Vector(k)			See [6] &EU.DK.255
13	1	M_BASIC_ASPECT_TYPE (k)	[If M_PER_RTSA_STATUS== 1] Basic Aspect Type	BITSET8	See [9] §2.1
14	2	M_EXTENSION_BASIC_ASPECT_TYPE (k)	[If M_PER_RTSA_STATUS== 1] Extension of basic aspect type	BITSET8	See [9]Signal Aspect Table, §2.2
15	3	M_SPEED_INDICATOR (k)	[If M_PER_RTSA_STATUS== 1] Speed indicator	BITSET8	See [9] Signal Aspect Table, §2.3
16	4	M_SPEED_INDICATOR_ ANNOUNCEMENTS (k)	[If M_PER_RTSA_STATUS== 1] Speed indicator announcements	BITSET8	See [9] Signal Aspect Table, §2.4
17	5	M_DIRECTION_INDICATOR (k)	[If M_PER_RTSA_STATUS== 1] Direction indicators	BITSET8	See [9] Signal Aspect Table, §2.5
18	6	M_DIRECTION_INDICATOR_ ANNOUNCEMENT (k)	[If M_PER_RTSA_STATUS== 1] Direction indicator announcements	BITSET8	See [9] Signal Aspect Table, §2.6

Table 11: Packet number 2: PER_SCV_SIGNAL_DETECTION

13.1.1.4 Packet number 3: SCV_PER_ACTIVE_CAB

Packet Number		**3**		
Item	**Variable Name**	**Description**	**Date Type**	**Resolution/Formula**
0	M_ACTIVE_CAB	Indicate the current active cab considered by SCV.	UINT8	**Value**: 0 = No active cab 1 = Cab 1 active 2 = Cab 2 active 3-7: spare

13.1.2 Interface C26

13.1.2.1 Static Data

13.1.2.1.1 The REP interface principle to provide the static data to REP customers must be defined within X2RAIL4.

13.1.2.2 Expected Signal Aspect Request

Item	**Variable Name**	**Description**	**Data Type**	**Resolution/Formula**
0	Q_ESARINIT	Qualifier for resuming the initial states of the related expected signal aspect request of the packet.	UINT8	**Value**: 0 = No initial states to be resumed, expected signal aspect request to follow

				1 = Empty expected signal aspect request, initial states to be resumed
1	NID_VIP	If Q_SDRINIT = 0 Identity of the virtual information point for which there is an expected signal aspect request.	UINT16	See 7.4.1.1.3

13.1.2.3 Expected Signal Aspect Response

Item	Variable Name		Description	Data Type	Resolution/Formula
0	NID_VIP		If Q_ESARINIT == 1 Identity of the virtual information point for which REP provides the Expected Signal Aspect Response.	UINT8	See 7.4.1.1.3
1	T_DATA		If Q_ESARINIT == 1 Timestamp when the signal aspect was provided by OE.	UINT32	Resolution: 1 ms
2	M_EXPECTED_CONFIDENCE		If Q_ESARINIT == 1 Confidence level of expected signal aspect, provided by OE.	UINT8	**Values:** 0 = for non-safe information 1 = for safe information
	Byte	Eulynx Signal Vector			See [6]&EU.DK.255
3	1	M_BASIC_ASPECT_TYPE	If Q_ESARINIT == 1 Basic Aspect Type	BITSET8	See [9] Signal Aspect Table 2.1
4	2	M_EXTENSION_BASIC_ASPECT_TYPE	If Q_ESARINIT == 1 Extension of basic aspect type	BITSET8	See [9]Signal Aspect Table, §2.2
5	3	M_SPEED_INDICATOR	If Q_ESARINIT == 1 Speed indicator	BITSET8	See [9]Signal Aspect Table, §2.3
6	4	M_SPEED_INDICATOR_ ANNOUNCEMENTS	If Q_ESARINIT == 1 Speed indicator announcements	BITSET8	See [9]Signal Aspect Table, §2.4
7	5	M_DIRECTION_INDICATOR	If Q_ESARINIT == 1 Direction indicators	BITSET8	See [9] Signal Aspect Table, §2.5
8	6	M_DIRECTION_INDICATOR_ ANNOUNCEMENT	If Q_ESARINIT == 1 Direction indicator announcements	BITSET8	See [9] Signal Aspect Table, §2.6

13.1.3 Interfaces C20/C62

13.1.3.1.1 Interfaces C20/C62 are defined in X2RAIL4.

13.1.4 Interface C17

13.1.4.1.1 The interface between SCV and Train Protection depends on the implementation strategy of SCV.

13.1.4.1.2 If SCV is meant to become a mean of transmission as defined in [1], then this new mean of transmission will impact [1].

13.1.4.1.3 If SCV is meant to become a mean of transmission as defined in [1], then the C17 interface must be defined in the Change Control Management of the ERTMS technical requirements.