OCORA

Open CCS On-board Reference Architecture

Virtual ETCS Transponder Service OB

Discussion Paper

Document ID: OCORA-TWS01-301

Version: 2.0

Date: 31.01.2025

Management Summary

Current ETCS systems requires many trackside physical balises for location purposes and giving location based information. These physical balises create many constraints and costs for the trackside and on-board ETCS systems: trackside asset installation, trackside maintenance cost increase (removing and reinstalling the balises for maintenance) and complex BTM system on-board.

The Virtual ETCS Transponder Service aims to reduces the costs and constraints linked to ETCS systems by exploiting new technologies introduced in the new CCS-OB architecture : ASTP, digital map and perception. VETS may also enable a significant increase of ETCS area of use, for instance by allowing trains to run in ETCS on unfitted lines.

The first revision of this VETS discussion paper is to introduce the problem statement and operational needs.

Revision History

Version	Change Description	Initials	Date of change
1.0	First Version	CM	21-06-2024
2.0	Official version for OCORA R6	CM	31-01-2025

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References

Reader's note: please be aware that the document ids in square brackets, e.g. [OCORA-BWS01-010], as per the list of referenced documents below, are used throughout this document to indicate the references to external documents. Wherever a reference to a TSI-CCS SUBSET is used, the SUBSET is referenced directly (e.g. SUBSET-026). OCORA always reference to the latest available official version of the SUBSET, unless indicated differently.

[OCORA-BWS01-010] – Release Notes
[OCORA-BWS01-020] – Glossary
[OCORA-BWS01-030] – Question and Answers
[OCORA-BWS01-040] – Feedback Form
[OCORA-BWS02-020] - Program Slide Deck
[OCORA-BWS02-030] - Technical Slide Deck
[OCORA-BWS02-040] - Program Posters
[OCORA-BWS02-050] - Technical Posters
[OCORA-BWS03-010] - Introduction to OCORA
[OCORA-BWS03-020] - Guiding Principles
[OCORA-BWS04-010] - Problem Statements
[OCORA-BWS05-010] - Road Map
[OCORA-TWS01-010] – Design Requirements
[OCORA-TWS01-011] – System Requirements
[OCORA-TWS01-020] – System Capabilities
[OCORA-TWS01-030] – System Architecture
[OCORA-TWS01-035] – CCS-On-Board Architecture
[OCORA-TWS01-100] – Localisation On-Board (LOC-OB) – Introduction
[OCORA-TWS01-101] – Localisation On-Board (LOC-OB) – Requirements
[OCORA-TWS01-102] – Localisation On-Board (LOC-OB) – Standard Communication Interface Specification
[OCORA-TWS05-010] – Requirements – Management Guideline
[OCORA-TWS05-020] – Stakeholder Requirements
[OCORA-TWS05-021] – Program Requirements
[OCORA-TWS05-022] – Design Requirements
[RCA.Doc.46] - Concept : Digital Map (BL0 R2)
[RCA.Doc.56] - Digital Map - Evaluation Publish Onboard Map Approaches (1.1 - 2021-11-30)
[EUG 21E109] - Vehicle Locator Concept Architecture, LWG, version 1.0, 2021-07-15
[TAURO D4.2 Appendix B] - Updated GoA3/4 Specification | Digital Map

1 Introduction

1.1 Purpose of the document

This document is the OCORA Virtual ETCS Transponder Service (VETS) discussion paper. This document introduces the problem statement of the current localisation by physical balises. To solve this problem, the VETS concept (terminology and main characteristics of the architecture) and high level requirements will be presented in a future release. All the concepts are still under discussion.

The requirements listed in this document will be developed from a VETS building block perspective. According to the OCORA definition, they are part of the OCORA D-Level requirements (refer to 1.4 - Requirements Engineering Process). The building block requirements (OCORA D-Level requirements) are detailing the OCORA system requirements [OCORA-TWS01-011].

The building block requirements captured in this document will be developed to reach a common understanding and communicate a precise OCORA view of the functional and non-functional requirements towards future VETS.

The building block requirements listed in this document will be prepared as an input for:

- EU-Rail and OCORA system architecture and design activities, shaping future TSI specifications, other legal frameworks, and other specifications
- Contracting entities, preparing tenders, and executing testing / certification activities for VETS

This document is addressed to experts in the CCS domain and to any other person, interested in the OCORA concepts for on-board CCS. The reader is invited to provide feedback to the OCORA collaboration and can, therefore, engage in shaping OCORA. Feedback to this document and to any other OCORA documentation can be given by using the feedback form [OCORA-BWS01-040] .
If you are a railway undertaking, you may find useful information to compile tenders for OCORA-inspired CCS building blocks, for tendering complete on-board CCS systems, or for on-board CCS replacements for functional upgrades or life-cycle considerations.
If you are an organization interested in developing CCS on-board building blocks according to the OCORA design principles, the information provided in this document can be used as input for your development.

1.2 Applicability of the document

The document is informative. Subsequent releases of this document will be developed based on a modular and iterative approach, evolving within the progress of the OCORA collaboration.

1.3 Context of the document

This document is published as part of an OCORA Release, together with the documents listed in the release notes [OCORA-BWS01-010] . Before reading this document, it is recommended to read the Release Notes [OCORA-BWS01-010]. If you are interested in the context and the motivation that drives OCORA we recommend to read the Introduction to OCORA [OCORA-BWS03-010], and the Problem Statements [OCORA-BWS04-010]. The reader should also be aware of the Glossary [OCORA-BWS01-020] and the Question and Answers [OCORA-BWS01-030].

1.4 Requirements Engineering Process

OCORA requirements elicitation follows the Requirements Management Guideline [OCORA-TWS05-010]. The requirements are engineered in a top-down manner:

- As a starting point all **Objectives** are captured. Objectives are the high-level goals to be achieved by developing an Open CCS On-Board Reference Architecture.
- Next, the program **Guidelines** are developed. They define tools, processes, methodologies and design rules to be used within the program and to be considered during the system analysis and the system design/architecture work.
- **References** to identified applicable Standards, Regulations and Specifications are captured.
- Stakeholder centric **Operational Epics** are captured and corresponding **Operational & System Requirements** de rived.
- Based on the System Requirements, the MBSE architecture work defines the Building Blocks taking into account all applicable **Guidelines**.
- All applicable requirements are apportioned to the identified building blocks, resulting in **Building Block Requirements** , used for tendering OCORA compliant Building Blocks.

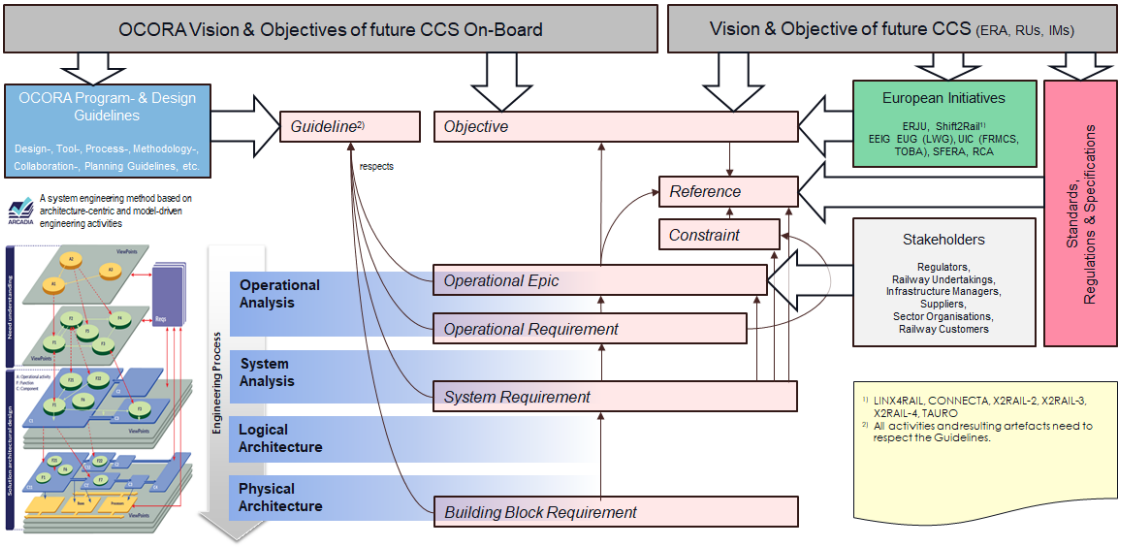


Figure 1 OCORA Requirements Engineering Process

Artefact	Description
Objective	Objectives define strategic approaches of what to do on a very high level and are formulated for the CCS Ob-Board.
Guideline	Guidelines describe OCORA program defined tools, processes, methodologies and design rules to be used within the program and to be considered during the system analysis and the system design/architecture work.
Reference	References point to external Standards, Regulations and Specifications that are relevant to the CCS On-Board.
Constraint	Constraints are specific artefacts of referenced Standards, Regulations and Specifications that may be linked to Operational Epics, Operational Requirements and/or System Requirements.
Operational Epics	Operational Epics describe a tangible vision or stakeholder need with a scope fitting the CCS On-Board. Epics do not follow the formal rules for requirements. However, they are formulated using a defined sentence template.

Artefact	Description
Operational Requirement	Requirements regarding operational processes and/or organisations derived from Objectives, Operational Epics and/or Constraints.
System Requirement	Requirements in regards to the CCS On-Board system are developed in the MBSE System Analysis, based on the Objectives, Operational Epics, Operational Epics, References and/or Constraints.
Building Block Requirement	Requirements in regards to the OCORA building blocks are developed in the MBSE System Architecture (logical / physical), taking into account the MBSE System Analysis.

Table 1 Requirements Management Artefacts

2 Operational analysis

2.1 Problem statement

Current ETCS systems requires many trackside physical balises for location purposes and giving location based information. These physical balises create many constraints and costs for the ETCS systems both on-board and trackside :

- Trackside asset installation, with area with few available free space.
- Trackside maintenance cost increase (removing and reinstalling the balises for maintenance)
- Complex BTM system on-board, introducing integration constraints and impacting system availability
- Complex system update, requiring to manually update the balises one by one
- Trackside deployment preconditioning ETCS operations

As an example, in some ETCS level 2 lines in France the distance between balise group varies from 50 to 1800m.

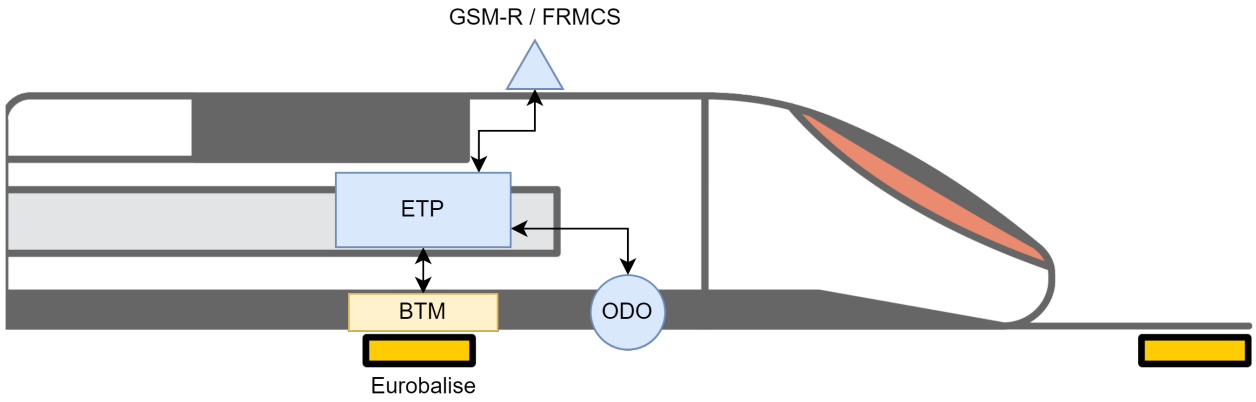


Figure 2 : current situation

The Virtual ETCS Transponder Service aims to reduces these costs and constraints by exploiting new technologies introduced in the new CCS-OB architecture : ASTP, digital map and perception.

In the future, the ASTP system will reduce the number of physical balise required for location purposes. VETS proposes to further reduce those balise by removing the physical balises required to transmit location based information.

Reducing the number of balises will :

- Lower ETCS deployment cost
- Lower trackside maintenance cost
- Easier and faster system update

Removing completely the needs for physical balise would further enable :

- Faster deployment of ETCS, and extending the ETCS area of use
- Reducing the ETCS-OB integration constraints by removing the BTM

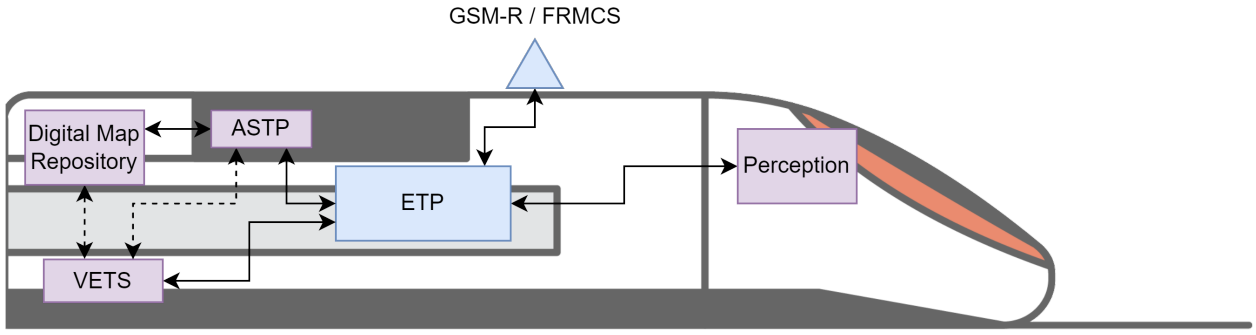


Figure 3 : VETS projected situation

2.2 Operational Epics

In the following section, identified key operational epics related to VETS are listed. These epics tackle down the pitfalls expressed above. All epics descriptions follow the same pattern :

- initially it is stated, who benefits from the epics (e.g. infrastructure manager, railway undertaking and/or supplier);
- then the epics itself is formulated;
- and finally the rationale of the epic is provided.

Also, the derivation of the Operational Epics from the Common Business Objectives from ERJU are shown. This link will ensure a continuity with System Pillar activities.

OCORA-10402 - Operational EPICS: Operate ETCS Level 2/3 without the need of physical balises

As an Infrastructure manager, I want the possibility to operate an ETCS Level 2 area without using physical balises or with a significantly reduced number of physical balises.

Status	Draft
Rationale	- reduced the number of trackside asset. - save time and money of the installation of physical balises. - save time and money of the maintenance of physical balises. - save time and money on the infrastructure maintenance : no need to remove and reinstall the balises - avoid complex installation of physical balises where there are no more free space. - reduce interference issues between balise and metallic mass on or near the track
Remark	This Operational EPIC applies for new deployement or update existing Level 2 by removing physical balises. This Operational EPICS would require a SIL 4 safety level for the VETS system : - The virtual balise will be used as a reference in the train location report to the trackside. - The VETS could be used to send national values or level transition order for example
Linked Work Items	refines : OCORA-8820 - overall CAPEX/OPEX optimisation(1) refines : OCORA-8822 - availability: less assets refines : OCORA-8812 - less trackside assets refines : OCORA-10492 - robustness against weather has parent : OCORA-8893 - Operational Epics is refined by : OCORA-10068 - C-level: Allow the removal of fixed physical balises is refined by : OCORA-10069 - C-level: Do not touch to the on-board localisation information referring to an LRBG

OCORA-10420 - Operational EPICS : Operate trains without BTM

As a railway undertaking, I want to operate train in ETCS without Balise Transmission Module.

Status	Draft
Rationale	- The BTM is a key system which impact the availability of the system - The BTM is a complex component to integrate (CEM constraints, physical space under the carriage)
Remark	This Operational EPICS would require a SIL 4 safety level for the VETS system : - The virtual balise will be used as a reference in the train location report to the trackside. - The VETS could be used to send national values or level transition order for example
Linked Work Items	refines : OCORA-8820 - overall CAPEX/OPEX optimisation(1) refines : OCORA-8822 - availability: less assets has parent : OCORA-8893 - Operational Epics is refined by : OCORA-10068 - C-level: Allow the removal of fixed physical balises is refined by : OCORA-10070 - C-level: Allow the removal of switchable physical balises is refined by : OCORA-10069 - C-level: Do not touch to the on-board localisation information referring to an LRBG

OCORA-10403 - Operational EPICS: restrict shunting movement without the need of physical balises

As an IM, I want the possibility to restrict shunting movement (to control the boundary of the allowed shunting area) without using physical balises or a significantly reduced number of physical balises.

Status	Draft
Rationale	- reduced the number of trackside asset. - save time and money of the installation of physical balises. - save time and money of the maintenance of physical balises. - avoid complex installation of physical balises, especially in shunting yard, where there are no more free space.
Remark	Thanks to the improvement of the Localisation-OB that can provide absolute safe train positioning, CCS-OB can determine its position in a Digital Map. Thanks to that, CCS-OB can detect when the train is crossing the limit of a shunting area. If an ETCS packet is associated to this limit, it can be received by a virtual balise included in the Digital Map. This Operational EPICS would require a SIL 4 safety level for the VETS system to restrict access to the main line for trains performing shunting movement
Linked Work Items	refines : OCORA-8820 - overall CAPEX/OPEX optimisation(1) refines : OCORA-8822 - availability: less assets refines : OCORA-8812 - less trackside assets refines : OCORA-10492 - robustness against weather has parent : OCORA-8893 - Operational Epics is refined by : OCORA-10068 - C-level: Allow the removal of fixed physical balises

OCORA-10404 - Operational EPICS: Allow ETCS trains on an infrastructure equipped with line side signals only (no ETCS trackside equipment)

As an IM, I want to allow the train to be supervised by ETCS without installing ETCS trackside equipment (e.g. by reading the light signal on the track using machine perception).

Status	Draft

Rationale	- avoid the deployement cost of physical ETCS trackside equipment. - ease the trackside migration to "physical" ETCS via a costless intermediat step. - increase the number of train equiped with ETCS by incraesing the number of kilometers of line equiped with ETCS - avoid the intermediat step of deployement of physical balises (with the assumption that the future of ETCS will be without physical balises)
Remark	In this operational EPICS, a safety analysis is required to allocate the safety requirements of the VETS system to achieve the global system safety level .
Linked Work Items	refines : OCORA-8820 - overall CAPEX/OPEX optimisation(1) refines : OCORA-8822 - availability: less assets refines : OCORA-8812 - less trackside assets has parent : OCORA-8893 - Operational Epics is refined by : OCORA-8892 - C-level: ETCS over Line Side signaling is refined by : OCORA-10068 - C-level: Allow the removal of fixed physical balises is refined by : OCORA-10070 - C-level: Allow the removal of switchable physical balises

OCORA-10422 - Operational EPICS : Operate train in ETCS on an infrastructure equipped with line side signals only (no ETCS trackside equipment)

As a RU, I want to operate a train in ETCS on an infrastructure with line side signals but not equipped with ETCS trackside assets (e.g. physical balises).

Status	Draft
Rationale	- accelerate ETCS on-board deployment - save cost by removing the need for on-board STM system - Extend the area of use of ETCS train - Increase overall safety on unfitted lines
Remark	In this operational EPICS, a safety analysis is required to allocate the safety requirements of the VETS system to achieve the global system safety level . This EPIC requires a safe perception system
Linked Work Items	refines : OCORA-8822 - availability: less assets refines : OCORA-8812 - less trackside assets has parent : OCORA-8893 - Operational Epics is refined by : OCORA-8892 - C-level: ETCS over Line Side signaling is refined by : OCORA-10068 - C-level: Allow the removal of fixed physical balises is refined by : OCORA-10070 - C-level: Allow the removal of switchable physical balises

OCORA-10423 - Operational EPICS: Operate a train with ATO over ETCS on an infrastructure equipped with line side signals only (no ETCS trackside equipment)

As a RU, I want to operate a train with ATO over ETCS on an infrastructure with line side signals but not equipped with ETCS trackside assets (e.g. physical balises)

Status	Draft
Rationale	- avoid the need for ATO over classe B system - accelerate standard ATO over ETCS deployement
Remark	- The grade of automation will have an impact on the VETS safety requirement. - The line can also be used by trains without ATO - Level 2: implicitly covered by OCORA-10402 - This EPIC requires a safe perception system

Linked Work Items	refines : OCORA-8822 - availability: less assets refines : OCORA-8812 - less trackside assets has parent : OCORA-8893 - Operational Epics is refined by : OCORA-8892 - C-level: ETCS over Line Side signaling is refined by : OCORA-10068 - C-level: Allow the removal of fixed physical balises is refined by : OCORA-10070 - C-level: Allow the removal of switchable physical balises

OCORA-10471 - Operational EPICS : Operate trains in ETCS level 1 with virtual euroloop

As an IM, I want to deploy virtual euroloop instead of physical euroloop.

Status	Draft
Rationale	- avoid EMC perturbation - reducing trackside assets - simplify track maintenance operation
Remark	Physical euroloop are not allowed to be deployed anymore (7.4.1 TSI 2023).
Linked Work Items	refines : OCORA-8812 - less trackside assets refines : OCORA-8822 - availability: less assets has parent : OCORA-8893 - Operational Epics is refined by : OCORA-10071 - C-level: Remove balise antenna (and BTM) is refined by : OCORA-10549 - C-level: Allow the removal of physical euroloop

OCORA-10472 - Operational EPICS : Temporary speed restriction

As an IM, I want to deploy temporary speed restriction virtual balise on every trackside, except in level NTC areas

Status	Draft
Rationale	- avoid work team to equip trackside with temporary balises and add Cover and/or VBC
Remark	The existing solutions using physical balises gives an assurance to trackside work team that the TSR is in the right place. In case of the deployment of such solution, feedback should be given to the work team on the effective deployment of the virtual TSR balises. The deployment and digital map management will need to be further analysed.
Linked Work Items	refines : OCORA-8812 - less trackside assets has parent : OCORA-8893 - Operational Epics is refined by : OCORA-10068 - C-level: Allow the removal of fixed physical balises

2.3 Use case illustration

These operational epics can be illustrated into two main use case :

- Removing LEU and switchable Eurobalise in ETCS level 1 :

Figure 2 ETCS dynamic informations

- Removing static information point (balise cover, level transition order Data used by applications outside the ERTMS, radio network configuration...) in level 2 and 3

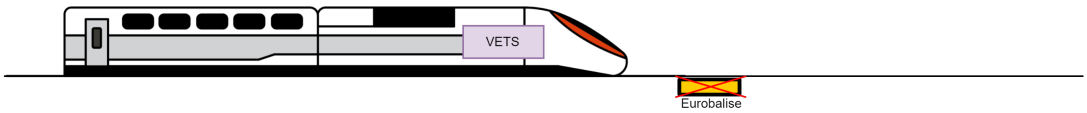


Figure 3 ETCS static information

2.4 Involved entities and actors

2.4.1 Trackside

2.4.1.1 Lineside signals

Trackside equipment that visually conveys instructions or provides warning of instructions regarding the driver's authority to proceed.

2.4.1.2 Digital Map

Trackside description database including virtual balise

2.4.2 On-Board

2.4.2.1 CCS-OB

Control-Command and Signalling On-Board

2.4.2.2 Repository (REP-OB)

On board repository storing the digital map.

2.4.2.3 Perception

CCS-OB component which will provide the state of upcoming lineside signalling.

2.4.2.4 Signal converter

CCS-OB component that will select the ETCS telegram corresponding to the signal state given by the perception system.

3 System analysis

3.1 Assumptions

This chapter lists all the assumption considered for the VETS system analysis and following requirement.

3.1.1 Required CCS-OB components

The VETS system requires other CCS-OB component to be operational :

- **An advanced safe train positioning system**, **outputting a safe train front-end position, including track selectivity**
- **A safe digital map**
- **A perception system** (to be able to operate on unfitted lines)

3.1.2 Localisation initialisation

As the virtual balise are positioned based on the location given by the ASTP, **the VETS system will not be able to replace relocation balises**. If the ASTP requires relocation balises (for uncertainty reset or initialisation), it shall continue to use physical balises.

3.1.3 Virtual an physical balise compatibility

In addition, having both physical balise and virtual balise would require a priority mechanism to process telegram from physical balise and virtual balise, adding complexity to the system.
Trackside engineering rule would therefore forbid placing virtual balise and physical balise at the same location.

Physical balise position are known in the digital map. A train without BTM could use the VETS to get the corresponding telegrams.

3.2 System capabilities

3.2.1 Fixed balise information

OCORA-10703 - C-level : List of static information
The VETS shall be able to send the following static packets :

- Virtual Balise Cover Marker (0)
- Virtual Balise Cover order (6)
- Level Transition Order (41)
- Data used by applications outside the ERTMS (44)
- Radio Network registration (45)
- Conditional Level Transition Order (46)
- Danger for shunting information (132)
- Stop if in Staff Responsible (137)
- Inhibition of balise group message consistency reaction (145)

Status	Draft
Classification	Requirement
Rationale	- provide ETCS level 2 informations without physical balises
Remark	
Linked Work Items	has parent : OCORA-10637 - Fixed balise information

OCORA-10548 - C-level : Limit impact on ETCS kernel functions
The VETS shall limit its impact on the ETCS kernel functions, for example by using the same interface as the PETS.

Status	Draft
Classification	Requirement
Rationale	- Limit costly development on the ETCS kernel - Limit the impacts on the ETCS kernel design
Remark	
Linked Work Items	requires : OCORA-10069 - C-level: Do not touch to the on-board localisation information referring to an LRBG has parent : OCORA-10637 - Fixed balise information

OCORA-10069 - C-level: Do not touch to the on-board localisation information referring to an LRBG

The CCS on-board shall remain the same by providing the localisation information referring to an LRBG (physical or virtual balise group).

Status	Draft
Classification	Requirement
Rationale	- to ensure backward compatibility with the existing ETCS on-board and trackside functionnality. - to not touch the existing interface between CCS-OB and RBC. (that could mean to be able to define a virtual balise as a "reference location" (cf. subset 023 for the definition of "reference location).
Remark	For instance, to continue to operate with a "classical" RBC, the CCS-OB shall continue to send a position report to the RBC referring to an LRBG.
Linked Work Items	refines : OCORA-10402 - Operational EPICS: Operate ETCS Level 2/3 without the need of physical balises refines : OCORA-10420 - Operational EPICS : Operate trains without BTM has parent : OCORA-10637 - Fixed balise information is required by : OCORA-10548 - C-level : Limit impact on ETCS kernel functions

OCORA-10068 - C-level: Allow the removal of fixed physical balises

The CCS-OB shall be able to operate without fixed physical balises or with a significantly reduced number of fixed physical balises.

Status	Draft
Classification	Optional Requirement
Rationale	- reduced the number of trackside asset. - save time and money of the installation of physical balises. - save time and money of the maintenance of physical balises. - avoid complex installation of physical balises where there are no more free space.
Remark	Thanks to the improvement of the Localisation-OB that can provide absolute safe train positioning, relocate the train with physical balises is less needed. But to continue to operate with a "classical" RBC, the CCS-OB shall continue to send a position report to the RBC refering to an LRBG.
Linked Work Items	refines : OCORA-10402 - Operational EPICS: Operate ETCS Level 2/3 without the need of physical balises refines : OCORA-10420 - Operational EPICS : Operate trains without BTM refines : OCORA-10403 - Operational EPICS: restrict shunting movement without the need of physical balises refines : OCORA-10404 - Operational EPICS: Allow ETCS trains on an infrastructure equipped with line side signals only (no ETCS trackside equipment) refines : OCORA-10422 - Operational EPICS : Operate train in ETCS on an infrastructure equipped with line side signals only (no ETCS trackside equipment) refines : OCORA-10423 - Operational EPICS: Operate a train with ATO over ETCS on an infrastructure equipped with line side signals only (no ETCS trackside equipment) refines : OCORA-10472 - Operational EPICS : Temporary speed restriction has parent : OCORA-10637 - Fixed balise information

OCORA-10070 - C-level: Allow the removal of switchable physical balises

The CCS-OB shall be able to operate without switchable physical balises or with a significantly reduced number of switchable physical balises.

Status	Draft
Classification	Optional Requirement
Rationale	- reduced the number of trackside asset. - save time and money of the installation of physical balises. - save time and money of the maintenance of physical balises. - avoid complex installation of physical balises where there are no more free space. - save time and money of the installation of LEU. - avoid complex interface design between LEU and "old" legacy interlocking.
Remark	Thanks to the improvement of the Localisation-OB that can provide absolute safe train positioning and technological advances in the field of perception, the replacement of switchable physical balises is possible.
Linked Work Items	refines : OCORA-10420 - Operational EPICS : Operate trains without BTM refines : OCORA-10404 - Operational EPICS: Allow ETCS trains on an infrastructure equipped with line side signals only (no ETCS trackside equipment) refines : OCORA-10422 - Operational EPICS : Operate train in ETCS on an infrastructure equipped with line side signals only (no ETCS trackside equipment) refines : OCORA-10423 - Operational EPICS: Operate a train with ATO over ETCS on an infrastructure equipped with line side signals only (no ETCS trackside equipment) has parent : OCORA-10637 - Fixed balise information

OCORA-10549 - C-level: Allow the removal of physical euroloop

The CCS-OB shall be able to operate without physical euroloop or with a significantly reduced number of physical euroloop .

Status	Draft
Classification	Requirement
Rationale	- reduced the number of trackside asset. - save time and money of the installation of physical euroloop. - save time and money of the maintenance of physical euroloop. - avoid complex installation of physical euroloop where there are no more free space. - save time and money of the installation of LEU. - avoid complex interface design between LEU and "old" legacy interlocking.
Remark	Thanks to the improvement of the Localisation-OB that can provide absolute safe train positioning and technological advances in the field of perception, the replacement of physical euroloop is possible.
Linked Work Items	refines : OCORA-10471 - Operational EPICS : Operate trains in ETCS level 1 with virtual euroloop has parent : OCORA-10637 - Fixed balise information

OCORA-10071 - C-level: Remove balise antenna (and BTM)

The CCS-OB shall be able to operate without balise antenna and BTM.

Status	Draft
Classification	Optional Requirement
Rationale	- save time and money of the installation of balise antenna. - save time and money of the maintenance of balise antenna. - avoid complex installation of balise antenna where there are no more free space undercarriage of the train.

Remark	Thanks to: - the improvement of the Localisation-OB that can provide absolute safe train positioning; - and the generalisation of the ETCS Level 2, or the technological advances in the field of perception; The use of physical balises is not necessary anymore. So we could remove the balise antenna from the on-board.
Linked Work Items	refines : OCORA-10471 - Operational EPICS : Operate trains in ETCS level 1 with virtual euroloop has parent : OCORA-10637 - Fixed balise information

OCORA-8892 - C-level: ETCS over Line Side signaling

CCS On-board shall be able to run on a track not physically equiped with ETCS (without physical balises, without physical LEU, without RBC).

Status	Draft
Classification	Optional Requirement
Rationale	- avoid the deployement cost of an ETCS area. - ease the trackside migration to ETCS via a costless intermediat step. - increase the number of train equiped with ETCS by incraesing the number of kilometers of line equiped with ETCS
Remark	
Linked Work Items	refines : OCORA-10404 - Operational EPICS: Allow ETCS trains on an infrastructure equipped with line side signals only (no ETCS trackside equipment) refines : OCORA-10422 - Operational EPICS : Operate train in ETCS on an infrastructure equipped with line side signals only (no ETCS trackside equipment) refines : OCORA-10423 - Operational EPICS: Operate a train with ATO over ETCS on an infrastructure equipped with line side signals only (no ETCS trackside equipment) has parent : OCORA-10637 - Fixed balise information

OCORA-10550 - C-Level: Database update

The CCS-OB shall have have the most recent balise information at any given time.

Status	Draft
Classification	Requirement
Rationale	- Avoid line operation disruption by updating all train running on the line - The balises information shall reflect at all time the real situation - Facilitate changes of the train area of use
Remark	- This update could be done remotely or locally
Linked Work Items	refines : OCORA-10495 - Operational EPICS : Database update has parent : OCORA-10637 - Fixed balise information

3.3 Black box analysis

As a first approach, we consider the new CCS-OB (VETS, VS, PETS, ASTP and VETS) as a black box and list all the functions required for the VETS, listed in the following functional chain. An allocation proposal will be given for each function in the following chapters.

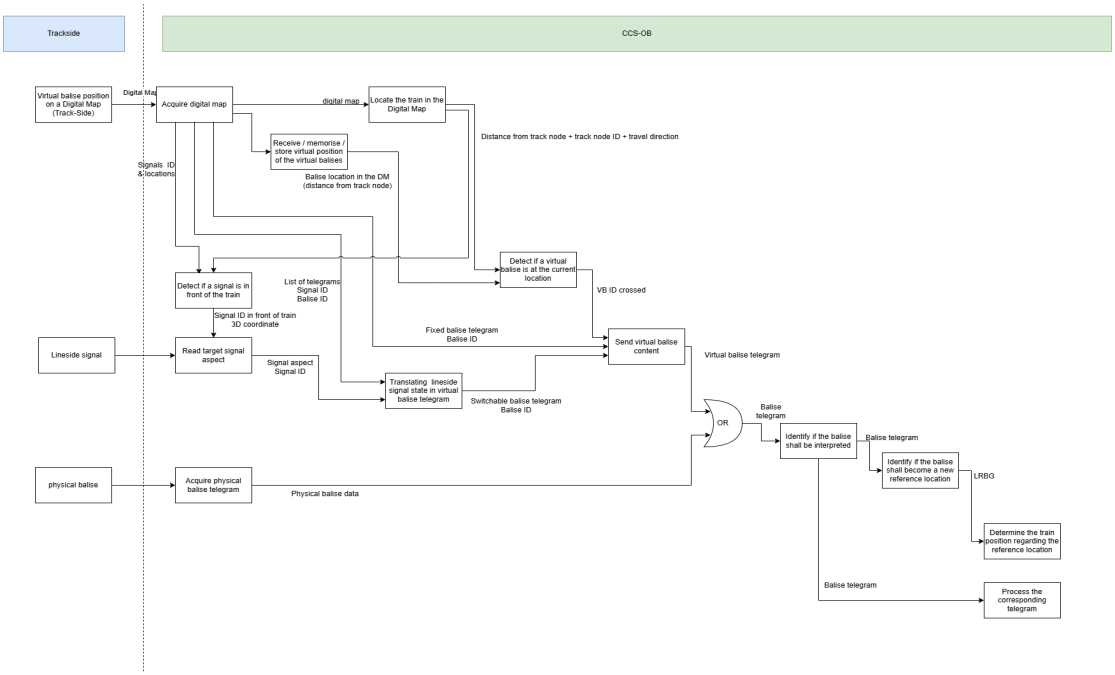


Figure 4 Virtual balise reception functional chain

Acquire Digital Map : CCS-OB acquires the latest version of the digital maps and stores it.

Receive / Memorize / Store virtual position of the virtual balises : The CCS-OB retrieves the virtual balises positions from the digital map

Locate the train in the digital map : the CCS-OB determines the train position within the digital map (1D position)

Detect if a virtual balise is at the current location : map matching function to detect virtual balise crossing by the train. Each virtual balise has a qualifier indicating whether it should be triggered on the max safe front end or estimated position.

Detect if a signal is in front of the train : map matching function to identify upcoming lineside signal

Read target signal aspect : Use perception sensor to detect upcoming lineside signal aspect

Translate lineside signal state in virtual balise telegram : retrieve from the digital map the ETCS telegram corresponding to the signal aspect

Send virtual balise content : retrieve the fixed balise telegram from the digital map, sends the balise telegram upon balise crossing. If needed, assembles fixed and switchable virtual balise data.

Acquire physical balise telegram : The CCS-OB acquires ETCS telegrams from physical balise on the track

Identify if the balise shall be interpreted : CCS-OB performs consistency check on the telegrams (linking information check, exclude forbidden values)

Identify if the balise shall become a new reference location : CCS-OB determines the reference location

Determine the train position regarding the reference location : CCS-OB locates the train (1D) regarding the latest reference location.

Process the corresponding telegram : CCS-OB performs the necessary actions according to the telegram content.

4 Logical architecture analysis

In this chapter, the CCS-OB functions described in the black box analysis are allocated to the CCS-OB logical components:

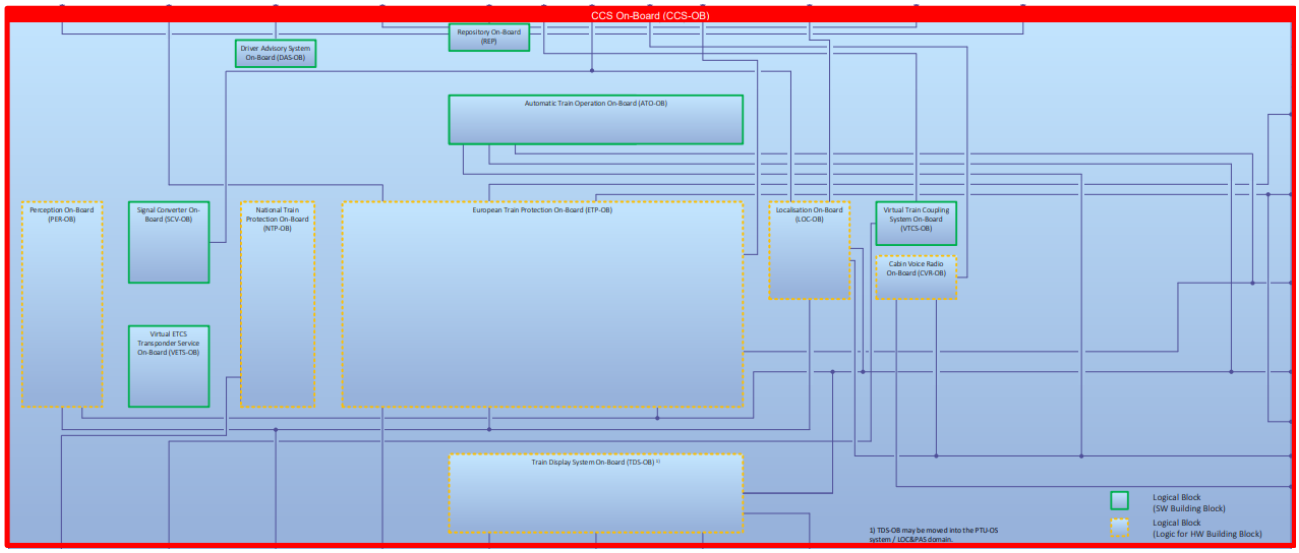


Figure 5 OCORA CCS-OB logical architecture [OCORA-TWS01-031]

The system functions are allocated to the following CCS-OB logical components :

- Repository On-Board (REP-OB)
- Localisation On-Board (LOC-OB)
- Signal Converter On-Board (SCV-OB) & Perception On-Board (PER-OB)
- European Train Protection On-Board (ETP-OB)
- Virtual ETCS Transponder Service On-Board (VETS-OB)

4.1 System function allocation

4.1.1 Repository On-Board (REP-OB)

4.1.1.1 Description

The digital map is stored on-board in the REP-OB.

The digital map is structured in layer, the first one being the common topology profile, containing the track description (track nodes and track edge). The virtual balise are contained in the signalling profile layer.

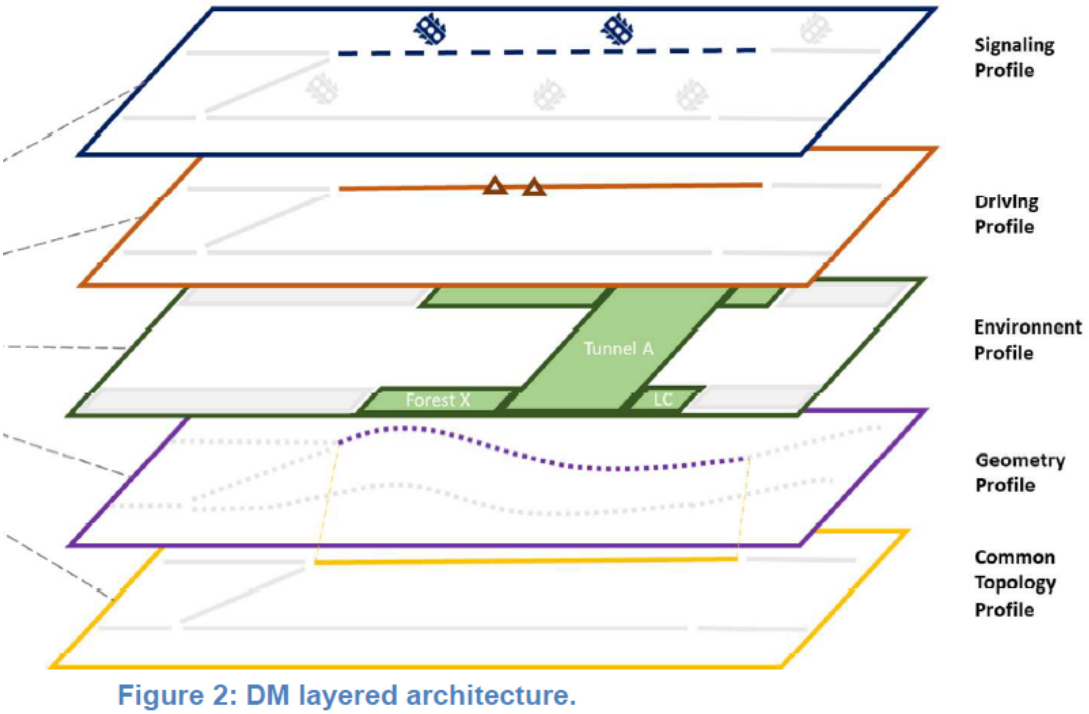


Figure 2: DM layered architecture.

Figure 6 TAURO digital map architecture [TAURO D4.2 Appendix B]

According to RCA, the virtual balise are referenced by two method :

- Referenced against geo-coordinate
- Referenced against a track edge and a distance from a track node. Each track nodes are located with geo-coordinate in the digital map.

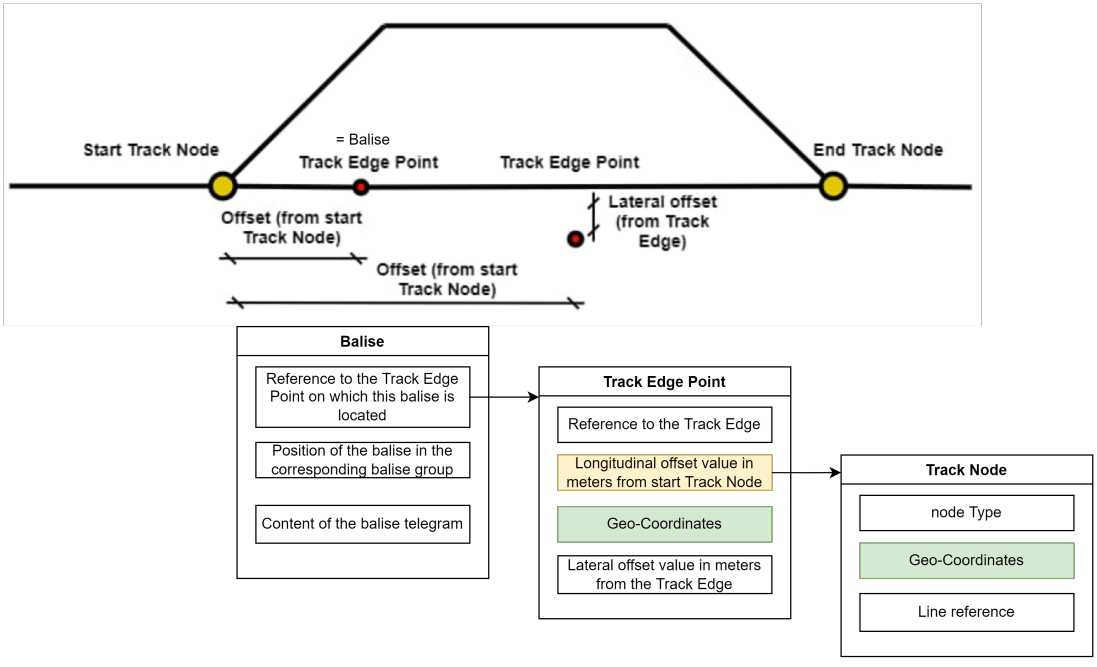


Figure 7 RCA digital map balise reference

4.1.1.2 Allocated functions

The following black box function are allocated to the Repository :

- Acquire digital map
- Receive / memorise / store virtual positions of the virtual balises

4.1.2 LOC-OB / ASTP

4.1.2.1 Description

The Advanced safe train positioning (or ASTP) is a new CCS-OB component aiming to provide the train position for all CCS-OB users, by using new sensors like GNSS. Therefore the train location in the digital map for the VETS will be provided by the ASTP.

The ASTP will provide to the CCS-OB :

- An estimated 3D position (no track selectivity)
- An estimated 1D position in the digital map, including :
  - Track edge ID & starting track node ID
  - Distance from track node
  - travel direction
- A safe confidence interval for the 1D position
- Distance from Last Relevant Balise Group (D_LRBG)

The interface with the ASTP is still under discussion within the train CS and might change in future release.

Initialisation & relocation

The VETS will use the position given by the ASTP to detect virtual balise crossing. Therefore, virtual balise cannot be used to :

- perform relocation of the ASTP position.
- initialize the ASTP on startup.

The VETS system will only be active if the ASTP is initiated and in safe operation.

4.1.2.2 Allocated functions

The following black box function are allocated to the ASTP :

- Locate the train in the digital map
- Determine the train position regarding the reference location

4.1.3 Signal converter and perception system

4.1.3.1 Description

The signal converter is the CCS-OB component which will provide the state of upcoming lineside signalling based on perception systems, train location and digital map data. The SCV is a virtual on-board LEU.

The SCV will output to the VETS the switchable balise telegram corresponding to the signal state.

The SCV and perception systems are merged into a single component in this release. The interface between the VETS, SCV and perception system will be detailed in future versions.

4.1.3.2 Allocated fonctions

The following black box function are allocated to the signal converter:

- Detect if a signal is in front of the train
- Read target signal aspect
- Translate lineside signal state in virtual balise telegram

4.1.4 ETP-OB

4.1.4.1 Description

The ETP-OB system receives the telegrams coming from the VETS (virtual balise) or the PETS (physical balise, read by the BTM).The ETP-OB will handle the balise data regardless of the telegram origin (virtual or physical balise). The ETP-OB will handle the telegram consistency check (linking information, forbidden values exclusion...), process the telegram content and determine the LRBG.

4.1.4.2 Allocated functions

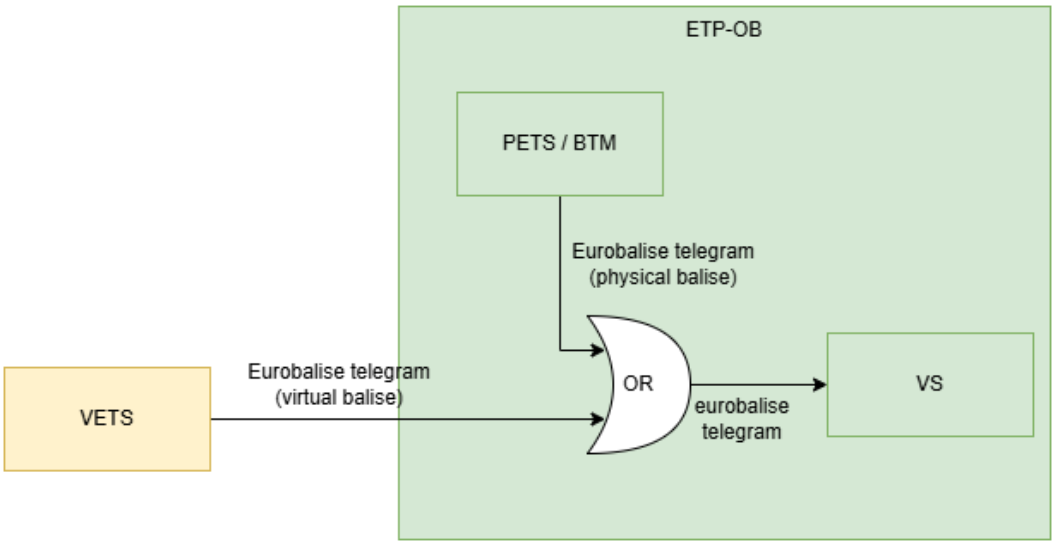
The following black box function are allocated to the ETP-OB:

- Identify if the balise shall be interpreted
- Identify if the balise shall become a new reference location
- Process the corresponding telegram

4.1.4.3 VETS or PETS interface

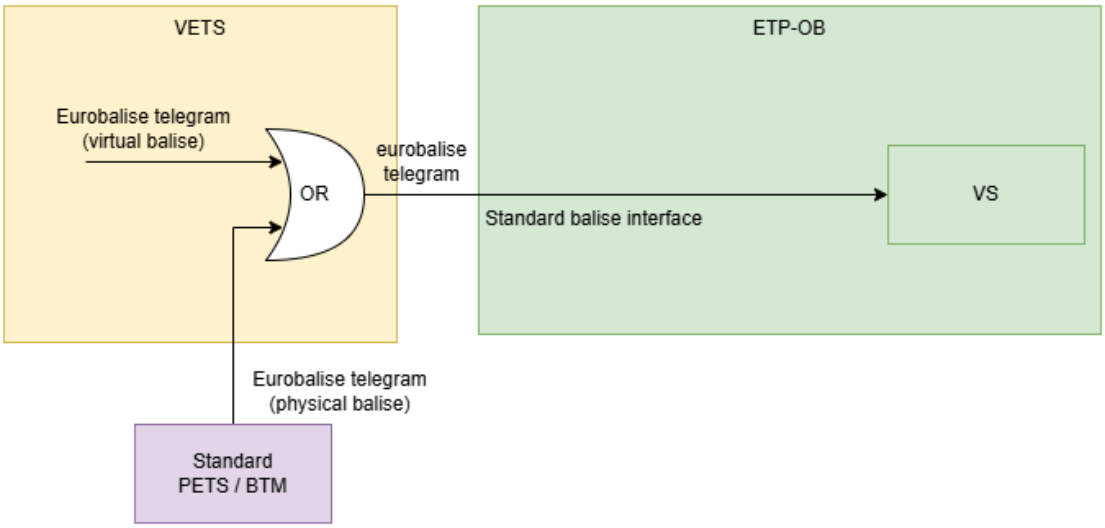
VETS aims to be transparent to the ETP-OB and have little to no impact by mimicking the PETS/BTM data. (OCORA-10548 - C-level : Limit impact on ETCS kernel functions). However, the PETS interface is proprietary and integrated within the ETP component, there is no standard interface for the balise telegram.
Two option are considered by the VETS working group for the interface with the ETP-OB. The choice between the option is still an open item, which is left for future release after discussion with the relevant actors.

Option 1 : The PETS component stays within the the ETP-OB and a new interface is created between the ETP-OB and VETS. The ETP-OB internally handles the "switch" between the telegrams coming from the PETS and VETS.



Option 2 : The PETS components is taken out of the ETP-OB scope and becomes a new standalone component. A new standard balise telegram interface is created on the ETP-OB. The "switch" between physical balise telegram and virtual balise telegram is handled by the VETS

Given complex development required to extract the PETS from the ETP-OB, this option is not privileged.



4.1.5 VETS

The VETS system will use the digital map data, the 1D train location from the ASTP and the signal aspect from the SCV to send the virtual balise telegram to the ETCS.

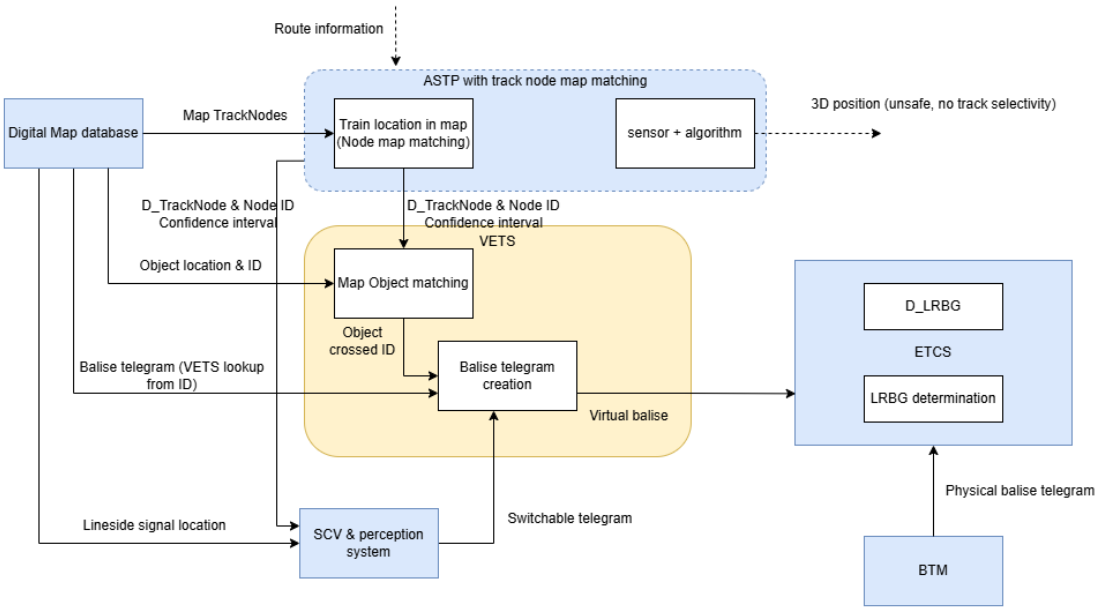


Figure 8 VETS system logical architecture

4.1.5.1 Allocated functions

The following black box function are allocated to the VETS:

- Detect if a virtual balise is at the current location. This allocation is still under analysis in the system pillar (Issue #1126), and might be revised in future release.
- Send the virtual balise content