OCORA

Open CCS On-board Reference Architecture

Localisation On-Board (LOC-OB)

High-level Requirements

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Revision History

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1.0	Official version for OCORA Release R1	SM	26.11.2021
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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-BWS03-010] - Introduction to OCORA

[OCORA-BWS04-010] - Problem Statements

[OCORA-TWS01-100] – Localisation On-Board (LOC-OB) – Introduction

[OCORA-TWS05-010] – Requirements – Management Guideline

[RCA.Doc.46, BL0 R2] - Concept : Digital Map

[RCA.Doc.18, BL0 R2] - RCA Domain Knowledge

[EUG 21E109] - Vehicle Locator Concept Architecture, LWG

1 Introduction

1.1 Purpose of the document

The purpose of this document is to provide the collection of all Localisation On-Board (LOC-OB) requirements in a structured manner. However, the current release focuses on the exported requirements of LOC-OB (see chapter 2 - Prerequisites), i.e. the requirements/needs LOC-OB has towards other components to fulfil its mission.
It is recommended to get familiar with the general Localisation On-Board principles [OCORA-TWS01-100] and the Vehicle Locator Concept Architecture [EUG 21E109] prior to reading this document.

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 compliant CCS building blocks, for tendering complete CCS system, or also for CCS replacements for functional upgrades or for life-cycle reasons.

If you are an organisation interested in developing CCS building blocks according to the OCORA standard, information provided in this document can be used as input for your development.

1.2 Applicability of the document

The document is currently considered informative but may become a standard at a later stage for OCORA compliant on-board CCS solutions. 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 the OCORA Release R1, 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

This OCORA requirement document is developed, using the Requirements Management Guideline [OCORA-TWS05-010]. The requirements are engineered in a top-down manner:

- As a starting point all **"Stakeholder Requirements"** towards the OCORA initiative **(A-Level requirements)** are captured and formalised.

- In a second step, the **"Program- and Design Requirements" (B-Level requirements)** are developed. These requirements 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.

- As a next step, the A- and B-Level requirements are further developed in the MBSE analysis to become **"System Requirements" (C-Level requirements).**

- As part of the MBSE architecture work, building blocks are identified taking into account the MBSE analysis (C-Level requirements). All applicable requirements (A-Level, B-Level, and C-Level) are apportioned to the identified building blocks, resulting in **"Building Block Requirements" (D-Level requirements)**, forming the OCORA tender templates, together with the applicable program & design requirements.

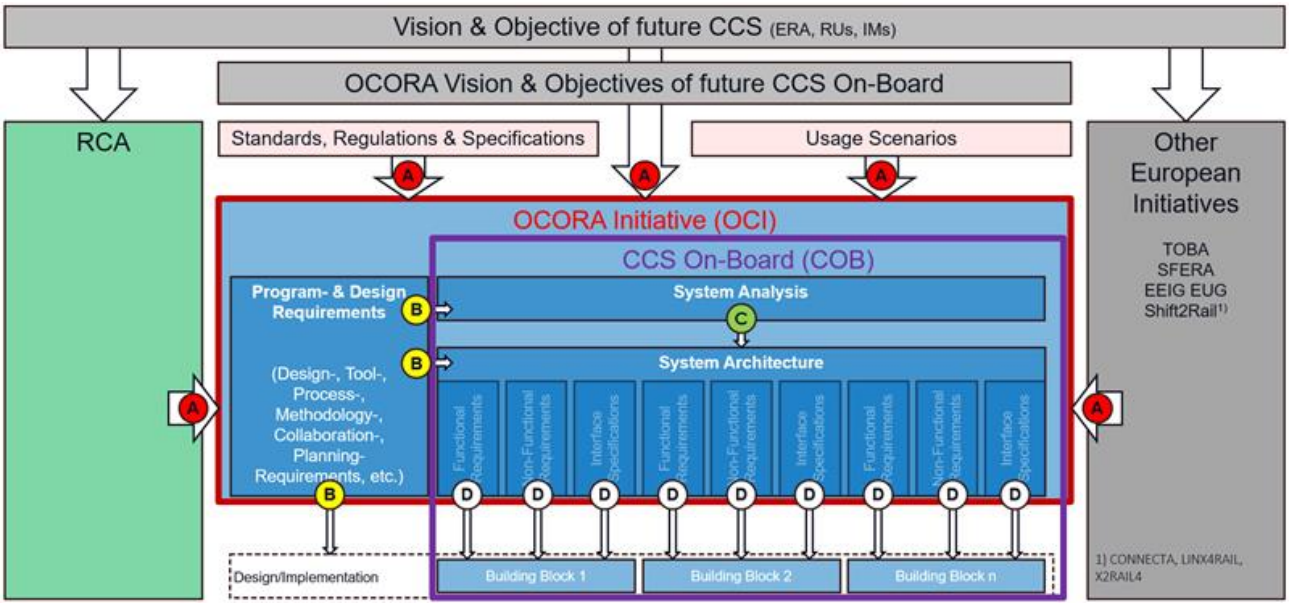

Figure 1 OCORA Requirements Engineering Process

Please note, that the A-Level requirements are applicable to the OCORA Initiative (OCI) while the B- and C-Level requirements are targeted towards the CCS On-Board System (COB) and its architecture. D-Level requirements are applicable to the respective building blocks.

2 Prerequisites

The prerequisites in this chapter represent a register of requirements towards other components of the CCS On-Board system. It is expected that the necessary functionalities and/or interfaces are realised as part of the linked component(s).

OCORA-986, D-Level - Augmentation Data improves localisation accuracy (SCI-AUG)

Augmentation Data leads to more accurate localisation information and faster estimation of accurate localisation after startup of the VL in operation.

Status	✓ Approved
Req. Class	Requirement
Req. Category	NFR non-RAMSS
Rationale	Augmentation data has to enhance GNSS localisation information to support functionalities such as track selectivity. Furthermore, involving augmentation has to result in faster accurate localisation estimation after the startup of the VL. Augmentation data is not limited to GNSS and could be supporting information such as temporary slippery conditions (rail friction coefficient) that can be regarded by the sensors and/or fusion logic to improve the overall performance.
Remark	In the Netherlands drivers are warned about slippery conditions.

OCORA-904, D-Level - Guaranteed availability of Augmentation Data wherever GPS and Galileo is available/usable (SCI-AUG)

Augmentation data is available for areas with GPS and Galileo availability.

Status	✓ Approved
Req. Class	Requirement
Req. Category	Availability
Rationale	Augmentation data has to be completely available to fulfil interoperability in application areas of ERTMS. It has to improve the navigation system's attributes, such as accuracy, reliability, integrity and availability, through the integration of external information into the calculation process. Augmentation data has to provide safe barriers against external feared events (fault and failures) of GPS and Galileo.
Remark	

OCORA-1005, D-Level - Augmentation provides safe corrections (SCI-AUG)

Augmentation data is provided through a safe process and has an integrity we rely on.

Status	✔ Approved
Req. Class	Requirement
Req. Category	Safety
Rationale	Since augmentation data is used to provide safe train localisation with better accuracy, augmentation data is safety relevant.
Remark	

OCORA-992, D-Level - Provide Cold Movement Detection Availability (SCI-CMD)

Cold movement detection is always available when exiting the ETCS No Power-mode (NP) with the subsequent exception. Information memorised by the Cold Movement Detection function is considered as not available if the Cold Movement Detection function has encountered a condition, during the ETCS No Power period, which prevents the use of the Cold Movement information (e.g. the battery, ensuring the Cold Movement Detection function, ran down during the No Power period).

Status	✔ Approved
Req. Class	Requirement
Req. Category	Availability
Rationale	Cold movement detection has to be always available to support the VL at startup. Technical solutions as GNSS/INS systems require a movement to align and calibrate their position after start up. Having the information if the train has been moved or not enables the option to determine a safe accurate position after startup already during standstill.
Remark	Subset-026-3.15.8.3, by also considering EUG CR1378

OCORA-987, D-Level - Provide Cold Movement Detection Power Off Durability (SCI-CMD)

Cold Movement Detection and recording is available at least for 72 hours after train power off.

Status	✓ Approved
Req. Class	Requirement
Req. Category	Availability
Rationale	VL (train position) and other ETCS functions (EOLM information, ERTMS/ETCS level, table of trackside supported levels, RBC ID/Phone Number) use the ouput of the same CMD function. Therefore, the availability of 72 hours is in alignment with the ETCS requirements from Subset-026. If the technical solution involves batteries, whose lifespan normally decreases, 72 hours mark a sufficient threshold for a maintenance reaction.
Remark	Subset-026-3.15.8.1

OCORA-915, D-Level - Record Cold Movement Detection Information (SCI-CMD)

CMD information provides:

- Movement flag
- Array of movement with travelled distances

Status	✓ Approved
Req. Class	Requirement
Req. Category	Functional
Rationale	The Vehicle Locator (VL) needs cold movement detection from the On-Board (CMD-OB), in order to validate if the position at power on is correct. The movement flag indicates, if a movement took place in general. Sometimes, slight movements can occur, for example during coupling. Therefore, information about the traveled distance is needed, to evaluate if the traveled distance is neglectable or can be even used for localisation correction.
Remark	UNIFE CR1345 Missing requirement for CMD function

OCORA-912, D-Level - Provide Cold Movement Detection at Power On (SCI-CMD)

CMD information is available at power on of LOC-OB.

Status	✔ Approved
Req. Class	Requirement
Req. Category	Availability
Rationale	The Vehicle Locator (VL) needs cold movement detection from the On-Board (CMD-OB), in order to validate if the position at power on is correct.
Remark	

OCORA-913, D-Level - Provide Cold Movement Detection According to Safety Requirements (SCI-CMD)

CMD information is determined and provided with the respective safety integrity requirements, e.g. is consistent with the Preliminary Hazard Analysis (PHA) result.

Status	✔ Approved
Req. Class	Requirement
Req. Category	Safety
Rationale	As stated in the CR1378, not having CMD information can lead to safety critical issues. Therefore, the provision of CMD information has to match safety integrity requirements accordingly.
Remark	Available products on the market provide for example SIL4.

OCORA-985, D-Level - Provide Train Integrity Status (SCI-TIS)

The train integrity information consists of

a) Train integrity status information

- No train integrity information
- Train integrity information confirmed by integrity monitoring device
- Train integrity information confirmed (entered) by driver
- Train integrity lost

Status	✔ Approved
Req. Class	Requirement
Req. Category	Functional
Rationale	The Train Integrity Information is needed, because the requirements of the VL permit a physical installation not only on the first coach (cab anywhere). Considering ETCS L3 without trackside integrity detection systems, the on-board train integrity information is crucial to report the train front position as "safe". In case the VL is installed in the first coach, train integrity information is not required.
Remark	Subset-026-3.6.5.2.3 VL concept architecture (ERTMS Users Group - LWG) [EUG 21E109]

OCORA-953, D-Level - Provide non-safe Time Information (SCI-TS-OB)

The Vehicle Locator (VL) needs accurate time information from the central Time Service On-Board (TS-OB) to determine the current localisation information (e.g. position, speed) at a common time.

Status	✓ Approved
Req. Class	Requirement
Req. Category	Functional
Rationale	Accurate time information is used to timestamp localisation information (position, speed, etc.) to know exactly where a train/vehicle has been at a certain point in time or in other words it's the time when the localisation information was valid. Localisation information with accurate time information • is beneficial in dense-traffic areas to optimise train scheduling (TMS plan optimisations/extrapolation) in near real-time. • simplifies error and event analysis as events are logged with accurate time information
Remark	A GNSS-based VL may collect time information directly through its GNSS sensor; however, to keep time consistency, the same time information needs to be provided to the central Time Service On-Board (TS-OB) component as a time input signal. See also CR EUG514 and UNIFE action 5.08 for further details on time-related requirements and use cases.

OCORA-982, D-Level - Provide safe Time Information (SCI-TS-OB)

Same requirement as stated in OCORA-953 but with the additional condition that the time information provided is safety-certified (SIL x) and is used for safety-relevant use cases.

Status	✓ Approved
Req. Class	Optional Requirement
Req. Category	Functional
Rationale	VL consumers use safe localisation information in combination with safe time information for safety-related use cases such as • level crossing time optimisation • timely warning of track workers (in parallel operation) • train length calculations and train integrity monitoring based on train front end and train rear end positions/speeds More generally speaking, VL needs safe time information to timestamp VL data (localisation information) for safety-related/-critical consumers.
Remark	It is assumed that the safe time provided by the Time Service On-Board (TS-OB) component originates from the safe computing platform. See also CR EUG514 for further details on time-related use cases.

OCORA-1004, D-Level - Allowed inaccuracy of time information (SCI-TS-OB)

A time inaccuracy of max. +/- 10 ms to a given UTC reference clock is acceptable.

Status	✓ Approved
Req. Class	Requirement
Req. Category	Availability
Rationale	Time information is required to timestamp the output of LOC-OB with the validity of the localisation information.
Remark	Considering a train at speed 140 km/h, a time inaccuracy of +/- 10 ms leads to a position inaccuracy of +/- 40 cm. For the time being, this requirement does not distinguish between safe and non-safe time information and is therefore valid for both cases.

OCORA-1001, D-Level - IP-based distribution of time information (SCI-TS-OB)

The time information is distributed through an IP-based protocol such as NTP v4 (RFC 5905).

Status	✔ Approved
Req. Class	Requirement
Req. Category	Functional
Rationale	NTP is the protocol defined by OCORA specification and is the de-facto standard protocol for time synchronisation in modern communication networks.
Remark	Time jumps during system initialisation or due to time synchronisation are allowed and must be handled by the VL. The influence of load on the network has to be regarded.

OCORA-1003, D-Level - First valid time signal (SCI-TS-OB)

A valid and stable time signal (within the specified inaccuracy band defined in OCORA-1004) is provided within xx seconds (also during system initialisation).

Status	✔ Approved
Req. Class	Requirement
Req. Category	Availability
Rationale	It is essential to guarantee a max duration until a valid/stable time signal is available, for example, not to delay the start of mission (SoM) process.
Remark	The actual value (xx seconds) has to be aligned at system level (part of SoM)

OCORA-983, D-Level - Provide Train Routing Information (SCI-TRI)

An interlocked (safe) train path is uniquely assigned to a train/vehicle.

Status	✔ Approved
Req. Class	Requirement
Req. Category	Functional
Rationale	This information is seen useful to validate the determined position by the VL against track selectivity, e.g. at startup after vehicle has moved during power-off mode (degraded mode). It might also be used to actually determine track selectivity, e.g. • if the vehicle position is known prior to passing a switch point and to decide whether it turned left or right • at start of mission (SoM) if vehicle has not been moved during power-off mode and previous location has been recorded
Remark	Today's ETCS Movement Authority (MA) specifies a distance (in meters) from a fixed, unique reference point (= balise group ID) up to which distance can be driven from this reference point. However, it does not specify a track-selective, unique route, for example, providing relevant track edge sections (see RCA domain knowledge [RCA.Doc.18, BL0 R2]) describing the interlocked train path. An ETCS MA (message 3) along with linking information (packet 5) provides the list of balise groups that the train is expected to pass on its route. Since the positions of all physical and virtual balise groups (each identified by a unique balise group id) are known by the digital map, the VL can use this information to determine the tracks that will be occupied by the train. Though, this is only a valid scenario as long as balise groups are defined consequently at the leg parts of each switch point to identify whether the left or right leg will be used and the selected mode of ETCS requires a MA. Another solution is to receive the position of each point (switch stand) as part of the interlocked train path (not covered yet by ETCS) that indicates a safe direction of travel (e.g., straight track, diverging track). Whether routing information can be used to actually determine track selectivity (not only for validation purposes) needs to be further analysed with respect to safety. In either case, the VL logic needs to avoid position jumps to other tracks if train routing information is suddenly interrupted.

OCORA-984, D-Level - Provide Physical ETCS Transponder Information (SCI-PETS)

Eurobalise Data Telegrams as specified in ERTMS/ETCS [SubSet-026, chapter 8] are provided every time the train passes or stands over a balise. At least the following fields are relevant for the VL:

- NID_C: Identity number of the country or region
- NID_BG: Identity number of the balise group
- N_PIG: Relative Position of the balise in the balise group
- Q_LINK: Marks a balise group as linked or unlinked
- time of balise passage (based on central Time Service On-Board (TS-OB) information: OCORA-953 / OCORA-982)

Hence, PETS provides information that enables the VL to evaluate the direction of the train on the basis of the reported sequence of passed balises.

Status	Approved
Req. Class	Requirement
Req. Category	Functional
Rationale	Depending on the algorithms used, balise information can be used as an absolute reference point (e.g., also in combination with digital map information) and reduce/reset the confidence interval (Subset-026-3.6.4.2.2). This information is also useful to validate the determined position by the VL against the matching physical reference position.
Remark	Only telegrams matching the following criteria are of relevance: • Q_UPDOWN = 1 (track to train) • Q_MEDIA = 0 (Balise) Subset-036-4.2.4

OCORA-993, D-Level - Provide Digital Map Data (SCI-DM-OB)

Digital Map On-Board (DM-OB) provides Digital Map Data according to the VL request.

Status	✓ Approved
Req. Class	Requirement
Req. Category	Functional
Rationale	Digital map data provides track description and the network topology. These information are useful for sensor fusion algorithms based on absolute positioning determination. While the train is travelling, if required, VL needs to extend the Digital Map Data according to the train path.
Remark	The Map Data includes a build-up set of edges along with associated nodes (e.g. points, buffer stops), the relevant infrastructure characteristics (e.g. curve radius and gradients), and location information (e.g. specific reference points, balises) [RCA.Doc.46, BL0 R2].

OCORA-994, D-Level - Integrity of Digital Map Data in compliance with VL safety goals (SCI-DM-OB)

The integrity, the accuracy and the currentness of Digital Map Data is compliant with VL safety goals.

Status	✓ Approved
Req. Class	Requirement
Req. Category	Safety
Rationale	Map data is used by VL functions in safety critical context. Map data shall not induce feared events in VL functions leading to hazards that can't be mitigated.
Remark	

OCORA-995, D-Level - Provide identification of active cab (SCI-ODS)

Operational Data Storage (ODS) sends to LOC-OB the identification of the active cab.

Status	✓ Approved
Req. Class	Requirement
Req. Category	Functional
Rationale	The status of the driver's cabs are required by the VL to determine the normal driving direction and the train front end. The status of a cab could be active, open or closed following an action by the driver. Only one cab is active on the train.
Remark	

OCORA-996, D-Level - Provide installation location of VL sensors with regard to the centre of the coach (SCI-CDS)

Configuration Data Storage (CDS) provides on request the configuration for VL sensors on the train with regard to the centre of the coach (coach where sensors are installed).

Status	✓ Approved
Req. Class	Requirement
Req. Category	Functional
Rationale	Positioning and orientation (if needed) of the different sensors is required by VL to compute accurate localisation information (position, speed...). E.g. correction between GNSS antenna and INS installation location.
Remark	

OCORA-1070, D-Level - Allowed inaccuracy of the installation location of VL sensors with regard to the centre of the coach (SCI-CDS)

The installation location inaccuracy of VL sensors with regard to the centre of the coach is less or equal to 5 cm.

Status	✔ Approved
Req. Class	Requirement
Req. Category	NFR non-RAMSS
Rationale	The accuracy is required by VL to compute accurate localisation information (position, speed...). E.g. correction between GNSS antenna and INS installation location.
Remark	The coordinate system (longitudinal axis and transversal axis) with an origin on the centre of the coach is used to define the location and orientation (if needed) of sensors.

OCORA-997, D-Level - Provide distance between the train front end and the centre of the coach (SCI-CDS)

Configuration Data Storage (CDS) provides on request the distance between the train front end and the centre of the coach where VL sensors are installed.

Status	✔ Approved
Req. Class	Requirement
Req. Category	Functional
Rationale	The distance is required to compute the train front end position.
Remark	Assumption: all sensors are installed in the same coach

OCORA-1071, D-Level - Allowed inaccuracy of the distance between the train front end and the centre of the coach (SCI-CDS)

The reported distance by CDS between the train front end and the centre of the coach is always equal or greater than the real distance (incl. coupling devices) and is max. 30 cm longer than its real distance.

Status	✔ Approved
Req. Class	Requirement
Req. Category	NFR non-RAMSS
Rationale	The maximum length is required to determine the most extreme position of the train front end.
Remark	For the engine-in-the middle scenario, the inaccuracy measure of 30 cm can be multiplied by the number of coaches coupled in front of the coach holding the VL sensor system.

OCORA-998, D-Level - Provide distance between two bogies of the coach (SCI-CDS)

Configuration Data Storage (CDS) provides on request the distance between the two bogies of the coach where VL sensors are installed.

Status	✔ Approved
Req. Class	Requirement
Req. Category	Functional
Rationale	The distance between the pivot of the two bogies of the coach is needed to make the correction of localisation information (e.g. speed, acceleration...) in curves between coach longitudinal axis and track centreline axis.
Remark	

OCORA-1072, D-Level - Allowed inaccuracy of the distance between two bogies of the coach (SCI-CDS)

The distance inaccuracy between the two pivot of the bogies of the coach where VL sensors are installed is less or equal to 5 cm.

Status	✓ Approved
Req. Class	Requirement
Req. Category	NFR non-RAMSS
Rationale	The distance between the two pivots is required to compute the localisation information in curves between coach longitudinal axis and track centreline axis.
Remark	

OCORA-1000, D-Level - Provide distance between the train front end and the balise reader antenna (SCI-ODS/SCI-CDS)

Data Storage On-Board (DS-OB) provides on request the distance between the train front end and the balise reader.

Status	✓ Approved
Req. Class	Requirement
Req. Category	Functional
Rationale	This parameter is required to process correctly physical balise detection and locate the balise in the digital map.
Remark	See Subset-040 Dimensioning and Engineering rules for balise reader requirements Alternatively, a balise reader antenna could be seen as a VL sensor whose requirement is covered by OCORA-996 and OCORA-997. However, a change in the existing Subset-040 would be required which is currently not anticipated.

OCORA-999, D-Level - Integrity of Data Storage On-Board (DS-OB) data in compliance with VL safety goals (SCI-ODS/SCI-CDS)

The integrity of DS-OB data is compliant with VL safety goals.

Status	✔ Approved
Req. Class	Requirement
Req. Category	Safety
Rationale	VL is providing safe localisation information to safety relevant consumers. Thus, train configuration and operational data has to comply with the safety goals of VL.
Remark	

3 Functional Requirements

- A GNSS-based Vehicle Locator shall be able to provide time information to the central Time Service On-Board (TS-OB).

Identification of functional requirements can be expected in subsequent OCORA releases.

4 Non-Functional Requirements

Identification of non-functional requirements can be expected in subsequent OCORA releases.