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| **Reference CCS Architecture** |  |  |
| ***An initiative of the ERTMS users group and the EULYNX consortium*** |  |  |

Digital Map - Concept

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**Change history**

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|  |  |  |  |

# Introduction

## Release Information

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## Purpose of the document

In December 2015, the European Union Agency for Railways (EUAR/ERA) defined different mid- and longer-term strategic challenges related to the ERTMS specifications roadmap in [5], listing the different lines of work for the development of the control and signalling system. The objective was to identify the optimal balance between (a) ERTMS Specification stability on one side and (b) their evolution (enhancements and errors) and ERTMS products on the other side, while safeguarding interoperability in the most economical way.

Among these so-called game changers, the sector identified the necessity of improving on-board localisation by the introduction of new positioning technologies (e.g. satellites). Several national tests and international research projects (e.g. GSA STARS, ERSAT GGC regarding the use of GNSS for railway localization) have shown, that a combination of sensors is required to ensure a more accurate and reliable (within the specified performance) odometry subsystem than the existing one and the use of additional technologies providing absolute or relative positioning in combination with map data can help to reduce trackside assets. In this context, on-board map data plays a central role as a kind of failure-free sensor, which delivers information about the track axis and relevant objects (e.g. reference points such as virtual or physical balises) to support the data evaluation and processing measured by the actual sensors. In addition, the on-board map allows to match corresponding positions in the railway system (e.g. distance on edge) based on the acquired sensor data information, i.e. for the geographical coordinates gathered by GNSS (or other) receivers or relative measurements done by IMUs.

To realize an interoperable and efficient solution, the required map data shall be provided via a standardized interface, not only for legacy but also for future railway architectures. Therefore, the Digital Map (DM) as a cluster has been launched as part of the RCA to cover the specification work. Besides as an RCA deliverable, it is also crucial to cover aspects of interoperability with the highest priority and summarize the results in a solution proposal of the CR1368 [10].

In addition, many other functions of the on-board or trackside railway systems rely on information about infrastructure, which can also be characterized as (Engineering) Map data, for the configuration of the systems (e.g. ATO, APS, TMS).

Over the course of this document the term ‘Digital Map’ is stated several times and is not to be confused with the actual ‘Map data’ itself. The following definitions in section 1.2 shall avoid any misinterpretations.

This document aims to provide a complete system view of the Digital Map, its main scope and principles, the expected environment as well as the objectives in terms of functional and non-functional requirements (NFR) that Digital Map pursues.

## Terms and Abbreviations

For terms and definitions refer to RCA DM Glossary [9]

## Definitions

The definitions provided here are to assist with better understanding and readability of the document. For complete list of all the other terms and abbreviations, refer to RCA DM Glossary [9]

1. Digital Map:

Digital Map is a set of functionalities providing track and trackside infrastructure information in the form of structured map data, including quality criteria for the data. In addition, it also ensures map management functionalities like map versioning, and download of map data.

1. Engineering Data:

Engineering data is a set of resulting data from the Engineering Process of Infrastructure Manager. Typically, the data are not adapted to cope with specific views demanded by each consumer. The engineering data contains all the base data (i.e. track topology and topography) for deriving the (engineering) map data during the compile process. The engineering data must fulfil engineering rules, that are influenced by requirements of (engineering) map data.
Engineering data contains only the updated resulting data (i,e, no several variants/versions of the same track) that is needed for the next provisioning and operation at a certain point of time in the consuming systems.

1. Map Data (also referred to as “engineering map data”):

Map data is provided to the consuming systems. During the operation, the map data is used to realize functions requiring map data, e,g, for support with on-board localization, generating ATO segment profiles, generating ETCS movement authorities or other specific use cases.
The (engineering) 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). The (engineering) map data remain unchanged during operation phase until the next provisioning of engineering map data.

1. Operational data:

Operational data is transmitted between production systems as part of messages, commands, requests, etc.. Operational data can refer to or contain required parts of (engineering) map data. In addition, operational data can contain temporary states or properties of infrastructure and its elements, that is overlaid on the (engineering) map data:

* The operational data is provided to consuming systems with information on the operational track infrastructure restrictions/properties i.e. usage restriction areas, temporary low adhesion zones, temporary speed restriction (TSR) areas. These restrictions/properties remain unchanged over time unless updated and can be overlaid on the (engineering) map data.
* In addition, the operational data is referred to the transient track assets state information e.g. point states or train track detection section states. This state information can also be overlaid on the (engineering) map data. It is to be noted that, these state information are not constant and vary as per train movements.
1. Safety-related data:

Safety-related map data refers to the data which are utilized by system functions, which have a pre-defined safety classification i.e., from SIL1 up to SIL4. These data for SIL functions, when imprecise/incorrect leads to a safety-related failure in the system.

*Note: the term “safety-related map data” is used to avoid the often used, but misleading term “SIL-data”, since the data itself does not have any SIL according EN 50126”*

1. Non-Safety-related data:

Non-safety-related map data represents any other data (complementary to safety-related map data), which does not require any safety-related requirements/classifications. However, this data must still fulfil a certain level of required quality, e.g. to guarantee a high level of availability.

1. Reliable Data

Reliable data refers to a typical characteristic of data which satisfies the qualities of being trustworthy/lower probability of incorrect information/lower fault rate of the information, current (not obsolete), complete, accurate.
Reliable data is not only about *safety-related data*, but also *non-safety-related* data that still needs to fulfil certain criteria for a specific function of consumer/system.

## Structure of the document

The document is structured as follows:

1. Chapter 2: Scope of Digital Map

Describes the scope of the of the digital map within the current RCA framework. Some of the possible consumers are listed and the role that the DM will play in the architecture is presented.

1. Chapter 3: Context of the cluster

Describes the background and the historical reasons that led the creation of the RCA DM Cluster and the main goals the group pursuits.

1. Chapter 4: Principles of Digital Map

Describes the principles of the DM function. Some high-level requirements are listed as the basis of the DM specification.

1. Chapter 5: Environment of Digital Map

Presents the Environment that will be used as basis to build up the function solution.

1. Chapter 6: RAMSS and performance requirements

Provides the list of Non-Functional Requirements that are applicable for the DM.

1. Chapter 7: Regulation analysis

Provides an insight on the list of regulations that are to be considered for development of DM.

1. Chapter 8: Exported requirements

Provides a list of high-level requirements that are exported from this DM concept document.

1. Chapter 9: Assumptions & Justifications

Provides a list of high-level assumptions at the concept phase of DM.

1. Chapter 10: References

 Provides a list of applicable documents and references.

# Scope of Digital Map

As defined in section 1.5, Digital Map also focuses on the structure and management of infrastructure data. To be precise, Digital Map addresses the interplay of the relevant RCA systems through definition of exchanged map data content between relevant RCA interfaces, map data quality requirements as well as the functional needs for relevant RCA systems to realize the Digital Map services including management functions.

Furthermore, in order to allow the applicability of Digital Map within legacy architectures, existing non-RCA systems (e.g. proprietary Map Servers, RBCs) are considered as a part of the environment, but not with the intention of designing a migration scenario, which is out of the scope for this cluster. For the time being, the focus lies with on-board localisation for components such as Vehicle Locator (VL) [2] for Train Protection applications (improvement of ERTMS odometer performances and second order effects like the reduction of number of virtual or physical balises).

However, it is not the only component that utilizes this data. Several other components in the RCA Architecture [2] concept, such as ATO, APS, TMS or MOL, PSL will also be consumers of the map data contained in the Digital Map. Therefore, the scope of Digital Map (regarding map data) will be extended in the next step to cover the needs of other safety-relevant and non-safety-relevant trackside and on-board systems. Digital Map will ensure the development of scalable requirements (e.g. data model or functions) depending on the needs of other stakeholders and phases*.*

Since this concept focuses on the providing map data via standardized interfaces to consuming systems and processes during the operation phase of the systems, the preparation and validation of map data are included later, see Figure 2.

 

Figure 2: Initial scope of DM and extensions

# Context of the Digital Map

As it was previously stated, Digital Map is one of the transversal functionalities that RCA envisages. Map data provided by the Digital Map may be consumed by many actors. This transversal usage of the data triggered the necessity of creating a transversal working group in which these needs, from the different consumers, could be considered.

The use of GNSS in the railway domain, was born about ten years ago with some train positioning research and innovation projects that highlighted the need of counting with a dataset to match the pseudo ranges provided by the signal in space with the rail infrastructure locations. It was in shift2rail X2R2-WP3 [6] where the sector started to develop a proposed architecture to tackle the on-board localisation problem while using GNSS as a source of information for on-board localisation to be integrated in the ERTMS system.

In parallel, railways, by means of the EUG Localisation Working Group (LWG), developed two documents owing to internal inquiries and positioning needs from rail operation. These two documents [7] and [8] set the high-level users' requirements for positioning and the accuracy targets of the on-board localisation system.

The EUG localisation working group produced, in December 2019, a change request (CR1368 [10]) for enhancing on-board localisation and reducing trackside asset, in the CCS TSI. The CR included the introduction of Digital Map functionality in the CCS specification. The problem description was accepted, and the CR was validated by the CCM process. At this point the LWG created a specific task force to design and agree on the concept of the Digital Map and its main functionalities, which are the seeds of the present cluster.

In parallel, the roadmap of RCA included the creation of a Cluster dedicated to the definition of the Digital Map functionality. Due to the background and knowledge gathered by the EUG through the activities carried out in the LWG and the special digital map task force, EUG was appointed responsible for this cluster.

Experts in digital maps, signalling, system engineering and system architecture, from the different railways are contributing to the work done in this cluster which aims to provide the definition of the Digital Map functionality and the definition of the interfaces using them.

Including the Digital Map functionalities in rail operations leads to different actions that need to be addressed, from the legal and operational point of view.

Independent of the solution or interface proposed, they need to guarantee interoperability throughout Europe. Using map data provided by Digital Map for the initial use case of improving ERTMS odometer performances, directly implies modifying the CCS TSI, to include the interoperability parameters of this new functionality. So, it can be used when integrated with ERTMS. This inclusion needs a safety analysis and a positive business case that will be checked and analysed by the CCS TSI CCM process. In addition, these deliveries serve as a base for the further specification work that needs to be done to provide, transport, and consume the map data by all systems that are part of this process or functionally rely on the Digital Map.

# Principles of Digital Map

The development of Digital Map shall pursue the following basic principles:

1. Universal: The developed solution shall aim at covering all relevant configurations and application scenarios and shall be neutral towards implementation. [REQ]
2. Simple: Architecture and data models shall be structured as simple as possible (e.g. avoid redundancies in the data model to prevent inconsistencies). [REQ]
3. Modular: The tailoring of consumer’s needs shall be done with aim at a clear separation of demands and considering operational and non-functional requirements of consumers (e.g. cut down consumer needs into groups with similar availability or safety requirements). [REQ]
4. Regionalising: The Digital Map data model shall allow the definition of different geographic areas. [REQ]
5. Maintainable: The Digital Map shall keep different versions of map data and ensure its maintainability and updatability. [REQ]
6. Future proof: The developed solution shall be usable for the long term and be easily extendable. [REQ]
7. Interoperable: Digital Map shall ensure interoperability across vendor solutions or infrastructure manager. [REQ]
8. Efficient: Digital Map shall define requirements that are not only technically feasible but also economically efficient (i.e. accuracy requirements and validity checks must not lead to unacceptable processing times or even technical barriers during the data preparation and validation. In addition, maintenance works such as tamping tracks should not lead to map updates due to too strong accuracy requirements without margin for maintenance phase) [REQ]
9. Reliable: Digital Map shall contain Reliable Data. [REQ]
10. Validity: The management process of Digital Map during operation phase shall ensure that the correct version of a map is provided to the consumer and outdated map versions (e.g. due to obsolete map data) are detected and are prevented of any use by consumer/system. [REQ]

# Environment of Digital Map

Figure 3  below represents a high-level overview of the system boundary of Digital Map. As stated in the Scope of Digital Map, the primary focus lies on providing map data for on-board localisation. As a result, the system boundary of the Digital map is illustrated as a region between the trackside and on-board systems.



Figure 3: Environment of Digital Map

On a high-level, Digital Map shall ensure fulfilment of functionalities based on the provision, content, structure, and management of the map data.

The fulfilment of these functionalities shall rely on,

1. Incoming (imported) requirements from the trackside/on-board systems.
	1. e.g. Map data shall satisfy pre-defined data characteristics ensuring reliable data.
	2. e.g. Map data for localization purposes shall include information about actual geometric track alignments
2. Outgoing (exported) requirements to the on-board/track side systems.
	1. e.g. On-board systems shall provide map services to download and use the map data from the trackside systems.

The requirements towards on-board systems are to be addressed along with OCORA, e.g. topics like use of Digital Map Service (DMS) as an on-board map data service provider. The alignment with OCORA on on-board localisation topics would also be an important factor for future development and in relation additional incoming/outgoing requirements may emerge as it evolves.

A detailed definition on applicable systems and interfaces shall be carried out in the system definition phase of development. This preliminarily defined system environment shall be considered as an input for the detailed system definition.

For the extended scope of Digital Map (i.e. with more subsystems, whole life cycle of map data) additional requirements regarding preparation, providing and applying of map data are expected. Therefore, these requirements are considered for further development in the next steps.

# RAMSS and performance requirements

This chapter provides an insight towards the different Non-Functional Requirements (NFR) which shall be considered throughout initial system development phases. As preliminary analysis the NFR’s, which have already been defined for existing systems [8][7]and RCA [2], has been collected and classified for the Digital Map based on a specific set of criteria.

The NFR’s applicable for the Digital Map shall focus on satisfying the following criteria,

1. Map structure/content e.g. data quality characteristics
2. Safety and security aspects
3. Map data management aspects i.e. versioning or downloading.
4. Map data availability aspects

Table 1: Applicable NFR's for Digital Map

| **Categories of NFR’s** | **From existing systems**  | **From RCA**  | **Applicable for Digital Map?** | **Applicability** |
| --- | --- | --- | --- | --- |
| Safety | Y | Y | Y | Safety shall ensure providing safety-related map data to consuming systems. [REQ]Also refer to Safety-related data and to digital map management functionalities. |
| Reliability | Y | Y | Y | applicable to map data. See Reliable Data. |
| Exchangeability | N | Y | N | Not applicable.Rational: Digital map does not cover the definition of the lower level interface layers but rather the upper level application layer. |
| Accuracy | Y | N | Y | Only applicable to map data. Accuracy shall ensure the parameters within map data are confined to pre-defined accuracy values. [REQ]e.g. The position of the reference point on the map and the real position along the track shall have a justifiable tolerance value to maintain map data accuracy.  |
| Availability | Y | Y | Y | Availability shall ensure that the map data is maximally available within the providing system for usage in case of a request from the consuming systems. [REQ] |
| Maintainability  | Y | Y | N | Not applicable.Rational: Applicable for the physical architecture of the system itself and Digital Map only defines the functional artefacts towards the consuming/providing systems.Also refer to Modifiability |
| Security | Y | Y | Y | Security shall ensure providing secure map data to the consuming systems avoiding undetected/ unintended manipulations. [REQ] |
| Capacity | Y | Y | Y | Capacity shall ensure the consuming/providing systems have sufficient minimum storage capacity to hold the map data for longer durations (in additional to other required data for operational purposes) as well as sufficient minimum transmission capacities over interfaces. [REQ] |
| Precision | Y | N | Y | Precision shall ensure the data are confined to pre-defined precision values, when subjected to repeated measurements. [REQ]e.g. A tolerance value between two sets of measured data.  |
| Resolution | N | N | Y | Resolution shall ensure the map data are confined to pre-defined minimum measurable distances. [REQ] e.g. The measurable distances on map shall be confined to minimum of x decimal points. |
| Environmental conditions | Y | N | N | Not applicable.Rational: Applicable for the physical architecture of the system itself and Digital Map only defines the functional artefacts towards the consuming/providing systems. |
| Physical robustness | N | Y | N | Not applicable.Rational: Applicable for the physical architecture of the system itself. |
| Time Behaviour | N | Y | Y | Only applicable for digital map management functions.Time behaviour shall ensure that consuming/providing systems do not lead to undesirable or unnecessary processing/response times for the map data. [REQ]  |
| Scalability | N | Y | Y | Scalability shall ensure the map data is scalable (up or down) corresponding to the required size of map data to be transmitted through the interface or content of the map data required by the specific consuming systems (scale by geographical region and by content). [REQ] |
| Reusability | N | Y | Y | Reusability shall ensure the characteristics/parameters/quality aspects of map data are reusable irrespective of consuming systems. [REQ]e.g. Map data is used by different subsystems of RCA and existing legacy subsystems |
| Portability | N | Y | N | Not applicable.Rational: Applicable for the software architecture of system itself and Digital Map only defines the functional artefacts towards the consuming/providing systems  |
| Adaptability | N | Y | N | Not applicable Rational: It is already covered in Modifiability |
| Modifiability | N | Y | Y | Only applicable to map data. Modifiability shall ensure the parameters defined in the map data are upgradable with any obsolescence/changes in existing information focusing on future data mode extensions/use cases/Consuming systems (structural updates). [REQ] |
| Testability | N | Y | N | Not applicable.Rational: Applicable for the software architecture of system itself. |
| Monitoring & Diagnostics | N | Y | N | Not applicable.Rational: Applicable for the software architecture of system itself. |
| Business Continuity Management | N | Y | N | Not applicable.Rational: Applicable for the overall development process of the systems itself. |
| Interoperability | N | Y | Y | Refer to Interoperable (see chapter 4) |
| Usability  | N | Y | N | Not applicable Rational: It is already covered in Reusability |
| Form and fit | N | Y | N | Not applicable.Rational: Digital map does not cover the definition of the lower level interface layers but rather the upper level application layer |
| Electromagnetic radiation / robustness | N | Y | N | Not applicableRational: Applicable for the physical architecture of the system itself. |
| Environmental protection | N | Y | N | Not applicableRational: Applicable for the physical architecture of the system itself. |
| Granularity  | N | N | Y | Only applicable to map data. Granularity shall ensure that the map data model is subjective to quantifiable level of detail. [REQ]e.g. Sampling of points that define the curve. |

Legends: Y- Yes; N-No

# Regulation analysis

## Interoperability

With the new 4th Railway Package, the rail regulation has had important changes. Interoperability regulations are the most important ones. Main legal documents that affect the train control and command systems are:

* Regulation (EU) 2016/796 on the European Union Agency for Railways. Describes the responsibilities of the European Rail Agency for system approval.
* Directive (EU) 2016/797 on the interoperability of the rail system within the European Union: describes the systems and subsystems to ensure the interoperability throughout Europe.
* Directive (EU) 2016/798 on railway safety: as its name suggests, stablishes the legal framework to perform risk evaluation processes, monitoring activities and safety assessments.

From these regulations a set of Technical Specification for Interoperability are born. Each TSI describes and specifies the rail system or subsystem to guarantee interoperability.

## Safety legislation/standards

According to the European directive 2016/798, compliance with the safety requirements shall be demonstrated to ensure the safe integration into the railway system and respect of the safety objectives when in service (for example, to achieve allocated THR’s for the localisation functions). In this context and following the Common Safety Methods (CSM) is allowed to apply the CENELEC standards. For the rail domain the following standards apply:

* EN 50126 Railway applications - RAMS, basic requirements, and generic process
* EN 50128 Railway applications - Communication, signalling and processing systems. Software for railway control and protection systems
* EN 50129 Railway applications - Communication, signalling and processing systems. Safety related electronic systems for signalling
* EN50159-1 Railway applications - Communication, signalling and processing systems Part 1: Safety-related communication in closed transmission systems
* EN50159-2 Railway applications - Communication, signalling and processing systems Part 2: Safety related communication in open transmission systems.

## Harmonization

Including the Digital Map in the current CCS architecture would lead to the amendment of the TSI and Technical Appendix. The new functionalities would be needed to be defined to ensure interoperability. This means that possibly, new subsets and some modifications to the already existing technical documents would be needed.

Within the RCA framework there exists a special Cluster that will deal with the migration strategies in more detail. However, this Digital Map Cluster has envisaged a proposal in which the functionalities of Digital Map could be accommodated in the current CCS TSI specification. Since as a part of current scope the map data is provided from trackside to on-board systems. The following relations to TSI exist and must be considered for Digital Map development.

 As a part of preliminary analysis, the different existing subsets in the CCS TSI specification would be affected:

* SS026. Changes related to odometry input, speed, and position. Change in the architecture. Specification of the message to send map information.
* SS034. Train Interface FIS, to include the onboard map data functions.
* SS041. Performance Requirements for Interoperability. To include the requirements for map data.
* SS091. Safety Requirements for the Technical Interoperability of ETCS in Levels 1 and 2. To include the safety cases due to the existence of the map data.

Depending on the ‘to be’ developed architecture new subsets might be required as well, possible examples could be:

* Possible new subset to specify the SCI-VL interface between the VL and the ETCS
* Possible new subset to specify the interoperability specifications of the VL
* Possible new subset to specify the interoperability specifications of the DM and its interface with the RBC.

## Further regulations

In addition, the following standards or models shall be considered for Digital Map development:

* RCA domain model (based on BNT approach) [11]
* RCA Capella modelling rules [12]
* Other general interface constraints of RCA AR cluster
* Compatibility to other standards, i.e. RTM (Rail Topo Model) and other RTM based formats such as
	+ EULYNX PREP [13]
	+ railML3 [14]

# Exported requirements

This chapter contains the list of all the high level requirements identified from the concept phase of Digital Map.

Table 2: Exported requirements from Digital Map Concept

|  |  |  |  |
| --- | --- | --- | --- |
| **Req. ID** | **Ref. Doc** | **Req. Type** | **Req. Description** |
|  | Digital Map Concept-Chapter 4 | Non-Functional | Universal: The developed solution shall aim at covering all relevant configurations and application scenarios and shall be neutral towards implementation |
|  | Digital Map Concept-Chapter 4 | Non-Functional | Simple: Architecture and data models shall be structured as simple as possible (e.g., avoid redundancies in the data model to prevent inconsistencies |
|  | Digital Map Concept-Chapter 4 | Non-Functional | Modular: The tailoring of consumer’s needs shall be done with aim at a clear separation of demands and considering operational and non-functional requirements of consumers (e.g. cut down consumer needs into groups with similar availability or safety requirements).  |
|  | Digital Map Concept-Chapter 4 | Non-Functional | Regionalising: The Digital Map data model shall allow the definition of different geographic areas |
|  | Digital Map Concept-Chapter 4 | Non-Functional | Maintainable: The Digital Map shall keep different versions of map data and ensure its maintainability and updatability |
|  | Digital Map Concept-Chapter 4 | Non-Functional | Future proof: The developed solution shall be usable for the long term and be easily extendable |
|  | Digital Map Concept-Chapter 4 | Non-Functional | Interoperable: Digital Map shall ensure interoperability across vendor solutions or infrastructure manager.  |
|  | Digital Map Concept-Chapter 4 | Non-Functional | Validity: The management process of Digital Map during operation phase shall ensure that the correct version of a map is provided to the consumer and outdated map versions (e.g. due to obsolete map data) are detected and are prevented of any use by consumer/system.  |
|  | Digital Map Concept-Chapter 4 | Non-Functional | Efficient: Digital Map shall define requirements that are not only technically feasible but also economically efficient (i.e. accuracy requirements and validity checks must not lead to unacceptable processing times or even technical barriers during the data preparation and validation. In addition, maintenance works such as tamping tracks should not lead to map updates due to too strong accuracy requirements without margin for maintenance phase)  |
|  | Digital Map Concept-Chapter 6 | Non-Functional | Reliable: Digital Map shall contain Reliable Data.  |
|  | Digital Map Concept-Chapter 6 | Non-Functional | Accuracy shall ensure the parameters within map data are confined to pre-defined accuracy values.  |
|  | Digital Map Concept-Chapter 6 | Non-Functional |  Modifiability shall ensure the parameters defined in the map data are upgradable with any obsolescence/changes in existing information focusing on future data mode extensions/use cases/Consuming systems (structural updates).  |
|  | Digital Map Concept-Chapter 6 | Non-Functional | Precision shall ensure the data are confined to pre-defined precision values, when subjected to repeated measurements.  |
|  | Digital Map Concept-Chapter 6 | Non-Functional | Reusability shall ensure the characteristics/parameters/quality aspects of map data are reusable irrespective of consuming systems.  |
|  | Digital Map Concept-Chapter 6 | Non-Functional | Safety shall ensure providing safety-related map data to consuming systems.  |
|  | Digital Map Concept-Chapter 6 | Non-Functional | Scalability shall ensure the map data is scalable (up or down) corresponding to the required size of map data to be transmitted through the interface or content of the map data required by the specific consuming systems (scale by geographical region and by content). |
|  | Digital Map Concept-Chapter 6 | Non-Functional | Security shall ensure providing secure map data to the consuming systems |
|  | Digital Map Concept-Chapter 6 | Non-Functional | Granularity shall ensure that the map data model is subjective to quantifiable level of detail.  |
|  | Digital Map Concept-Chapter 6 | Non-Functional | Availability shall ensure that the map data is maximally available within the providing system for usage in case of a request from the consuming systems.  |
|  | Digital Map Concept-Chapter 6 | Non-Functional | Capacity shall ensure the consuming/providing systems have sufficient minimum storage capacity to hold the map data for longer durations (in additional to other required data for operational purposes) as well as sufficient minimum transmission capacities over interfaces.  |
|  | Digital Map Concept-Chapter 6 | Non-Functional | Resolution shall ensure the map data are confined to pre-defined minimum measurable distances.  |

# Assumptions & Justifications

The assumptions here are a collection of boundary conditions, which were collected to narrow in on a temporary decision to complete this phase and take forward the developments to next phase.

Table 3: List of assumptions from Digital Map concept

|  |  |  |
| --- | --- | --- |
| **Assumption ID** | **Ref. Doc** | **Assumption Description** |
|  | Digital Map Remit  | Digital Map shall allow different physical implementation of the interface (tethered map update or over-the-airgap update) |

# References

The following documents provide related references:

1. RCA white paper: the rationale for starting RCA (published in august 2018): available here <https://ertms.be/workgroups/ccs_architecture> and here <https://www.eulynx.eu/index.php/home2/37-reference-ccs-architecture-white-paper> [RCA.Doc.1].
2. RCA System Concept [RCA.Doc.15]
3. RCA/OCORA: A potential harmonized On-board and Trackside Computing Platform for Digitalised Rail Operation
4. RCA System Architecture [RCA.Doc.35]
5. ERTMS Longer Term Perspective Report 18/12/2015
6. D3.2 System Architecture Specification and System Functional Hazard Analysis of the of the Fail-Safe
7. 18E112 TL high level principles
8. 19E100 Localisation Performance Requirements
9. Digital Map Glossary [RCA DM Glossary]
10. 20E073 Digital Map management for localisation purposes in ERTMS domain [CR1368]
11. RCA Domain Knowledge [RCA.Doc.18]
12. RCA Methods and Tooling [RCA.Doc.33]
13. EULYNX PREP, snapshot model provided on <https://eulynx.eu/index.php/dataprep> (2021-03-18)
14. railML3, schema provided on <https://www.railml.org/files/download/schemas/3.1/documentation/railML3.html> (2021-03-18)