RCA

Reference CCS Architecture

An initiative of the ERTMS users group and the EULYNX consortium

RCA – FAQ (frequently asked questions)

Document id: RCA.Doc.07

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Version history

Version	Date	Author	Description
1.0	30.09.2022	Roman Treydel	Version for RCA Baseline 1 Release 0

1 Introduction

1.1 Release information

Basic document information:

RCA-Document Number: 07
Document Name: RCA – FAQ (frequently asked questions)
Cenelec Phase: N/A
Version: 1.0
RCA Baseline set: BL1 R0
Approval date: 2022-09-30

1.2 Imprint

Publisher:

RCA (an initiative of the ERTMS Users Group and EULYNX Consortium)

Support and Feedback:
For feedback, or if you have trouble accessing the material, please contact rca@eulynx.eu.

1.3 Purpose of this document

This document contains frequently asked questions regarding different high-level topics connected to RCA. It aims to help understanding RCA.

2 Goals and direction

2.1 What is RCA?

RCA (= reference CCS[1] architecture) is a harmonised reference architecture[6] for the future railway CCS, with the main goal to substantially increase the performance / TCO[2] ratio of CCS.

2.2 Why RCA?

EUG/EULYNX members recognise that they cannot obtain the best solutions at national level, but need to develop/specify and migrate to one common reference architecture. Economies of scale will increase the market attractiveness introducing new suppliers, increasing competition, while enabling substantial costs savings for railways.

Further background can be found in:

- RCA white paper: https://ertms.be/workgroups/ccs_architecture
- RCA video: https://eulynx.eu/index.php/videos/68-rca-in-a-nutshell

2.3 How will RCA help?

RCA:

- defines standardised, evolvable interfaces for all major components of the future railway CCS;
- defines a target reference architecture without legacy systems, while providing a migration path[3];
- Increasing technology adoption bringing the railways into the innovation lifecycle[7].

RCA helps IM achieve the following goals[4]:

- substantial business cases (some railway companies have already calculated a case for an RCA-based systems);
- substantial capacity increase;
- safety increase for shunting, for track workers;
- energy savings.

2.4 What is the status of RCA?

RCA development started with three early releases called Alpha, Beta and Gamma which provided high-level concepts. With Baseline 0, work was started to produce model-based documents.

The latest Baseline 1 Release 0 represents a matured view on the RCA work achieved so far and consists of

- Documents based on Model Based Systems Engineering demonstrating how systems engineering can be performed following a strict process,
- Concept documents explaining the main ideas of RCA and
- Supporting documents.

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[1] CCS = control-command and signalling

[2] TCO = total cost of ownership i.e. including initial procurement and lifecycle costs, as well as direct and indirect costs

[3] the migration path will, of course, include legacy systems in most cases

[4] some of these effects are based on known mechanisms such as moving block, ATO etc. RCA does not pretend to invent new mechanisms “on top” but provides a coherent architecture to use those mechanisms.

[6] Reference Architecture where the structures and respective elements provide templates for concrete software based systems implementations.

[7] – Innovation lifecycle is a technology adoption lifecycle describing the acceptance of new products or innovation.

2.5 Will RCA fully harmonise business processes of the railway companies?

RCA provides an architecture with well-defined “building-blocks”. To be able to design useful building blocks, RCA will enable generic harmonised requirements. The building blocks of RCA can be used to support (according to the chosen equipment and configuration) different business processes. A (welcome) side effect may be some harmonisation of business processes resulting from using the same “building-blocks”. Full harmonisation is not required however, as long as interoperability is ensured.

Harmonisation of the business processes will be facilitated (but not become easy) through the fact that RCA targets a pure future state without class B systems.

2.6 Is ATO in scope of the RCA?

Yes, ATO is a key part of RCA, but is optional. RCA supports all Grade of Automation (GoA) from manual train operations up to fully automatic operations (GoA1 to GoA4).

2.7 Are vehicles in scope of the RCA?

Yes, the RCA scope includes modified functions on the vehicles and the corresponding interfaces to the vehicles. The scope of RCA does not include the architecture of the implementation of the components on the vehicles. A (separate) “reference vehicle architecture” initiative is needed to reduce the cost of bringing CCS functions to the vehicles.

Several railways have started the initiative “OCORA” (Open CCS on-board reference architecture), focusing on how to efficiently implement upgradable CCS function on the vehicle. More information: https://github.com/OCORA-Public/Publication

2.8 Are trackside assets in the scope of RCA?

The physical trackside assets per se are out of scope. For the interfaces to trackside assets RCA will reuse / build on material & processes of EULYNX.

2.9 Is a traffic management system (TMS) in the scope of RCA?

A TMS typically has several functional blocks, including:

1. Designing, developing and testing the operational plan (long-term and short-term).
2. Interfacing with neighbouring business processes such as path requests and planning tools of RUs.
3. Plan execution.

In RCA, controlling the plan execution (3) is in-scope (components PE and AE), including the interfaces to access the operational plan. The functional areas (1) and (2) are out of scope.

2.10 Is RCA a standard?

RCA is not a formal, “de jure” standard. RCA is a set of specifications. If the specification is credible and is used for substantial procurements, it creates a “de facto” standard or a “user standard”. This is the same approach as EULYNX.

2.11 ERTMS is already a standard, why do we need more?

ERTMS is an important standard and a foundation for RCA. The main thrust of ERTMS is the standardisation for interoperability. There are several areas (not relevant for interoperability) where the railways would benefit from stronger harmonisation of their equipment / components. RCA addresses some of these areas, based on a coherent overall architecture.

2.12 RCA, EULYNX, OCORA – so many initiatives. What’s going on?

RCA, EULYNX, and OCORA are all railway-initiated initiatives aiming at establishing a reference architecture for a clearly scoped domain. RCA focuses on a future CCS architecture. OCORA focuses on the optimisation of the on-board technology to support CCS. EULYNX focuses on today’s interlocking-based architecture.

There is strong interaction between these 3 initiatives. The initiatives are coordinated and follow a single development stream for CCS evolution and long-term compatibility.

2.13 What is the relation between RCA and EULYNX?

RCA and EULYNX are coordinated and related in several ways:

- The EULYNX organisation is (together with EUG) one of the governing bodies of RCA.
- The principle of railway companies harmonising requirements to define standardised interface specification is the same.
- RCA will directly include specifications from EULYNX in its overall architecture.
- EULYNX provides a migration path to RCA.
- RCA will re-use methods (modelling) developed in EULYNX.

The main difference between RCA in EULYNX is the scope of the architecture, EULYNX is forming part of the RCA scope. Moreover, RCA targets a simplified “pure” future architecture of a CCS system and the migration to it, while EULYNX targets also today’s architecture and enables the migration to RCA.

2.14 What is the relation with well-known “digital” railway programmes?

Several railways have announced / started substantial modernisation programs (e.g. Target190+, Digitale Schiene Deutschland, smartrail 4.0, and others). The goal of RCA is to use these programs as contributors for the harmonised development of RCA and to base these programs on RCA. On 13.6.2019, the three railways have signed a joint declaration of intent to that effect.

2.15 How does RCA relate to Europe’s Rail?

Europe’s Rail is a huge development program organised by the European Commission to drive standardisation and innovation in railways. It consists of two parts: The System Pillar focuses on standardisation of operations and system architecture whereas the Innovation Pillar hosts many research & development projects for innovative technologies.

The ideas of RCA influenced the set-up and definition of Europe’s Rail. Railways and industry already worked together on a high-level system picture in the European Railway Joint Undertaking (ERJU) System Pillar ramp-up project, which used mainly ideas from RCA and Shift2Rail as input. It is foreseen that more RCA work can be shifted to System Pillar with its start in late 2022.

The Innovation Pillar contains a demonstrator to show ETCS L3 Moving Block based on concepts from RCA and Shift2Rail. Detailed technical development is foreseen to take place there starting in 2023.

More information: https://rail-research.europa.eu/about-europes-rail/

3 Target architecture

3.1 What is the foundation of the target architecture of RCA?

RCA is based on radio-based ERTMS/ETCS cab-signalling.

3.2 Is RCA the same thing as ERTMS, totally different or a competition?

The RCA is a generic CCS architecture, that uses the ERTMS standards (TSI CCS). The protocols of ERTMS/ETCS are useful and important for interoperability. RCA implements advanced CCS functions like moving block, full supervision for shunting, high quality mobile localisation, etc. and adds interface specifications, that have not been necessary for interoperability, but which are crucial for evolvability and integrability. To fully use RCA, some change requests to the TSI will be necessary, which will be submitted in due form.

3.3 Does RCA include ERTMS "game changers"?

Yes, some of the game-changers frequently mentioned[5] are: automatic train operation,

full moving block, train-borne localisation (sometimes called satellite positioning, which is misleading) and the next generation telecommunications system. RCA implements all these game changers and additionally some innovations concerning interlockings and migration technologies. For localisation no particular technology (i.e. satellites) yet is favoured or believed to fulfil all needs, it will be an open architecture in which different technologies can be combined.

New braking curves are also considered as game changers. RCA does not work on braking curves but welcomes initiatives to optimise braking curves in the future.

3.4 Is there only one target architecture for RCA?

No, RCA-based system can choose different functional target configurations, without jeopardising interoperability. Possible variants in target architecture include: ATO (none – GoA2 - GoA3 – GoA4), the choice / mix of localisation technology, physical deployment (centralisation / regionalisation), and others. Also, an RCA-based system can exist in different physical / deployment configurations. A system is RCA-based, if its components implement the RCA interfaces.

3.5 Does RCA put at risk planned / on-going ERTMS deployments?

RCA does not put at risk planned / ongoing ERTMS deployments but provides an opportunity to enhance such programmes. Implementation of RCA into existing deployment programmes will need to be managed on a country-specific basis due to the varying drivers behind each country's deployment plan. It is expected that RCA will provide opportunities to reduce cost and improve availability and capacity. So, RCA does not fundamentally put at risk the current ERTMS deployments because:

- RCA is based on ERTMS
- Changes needed to the TSI will go through the official change process
- RCA includes mechanisms helping to migrate
- RCA includes mechanisms for future upward compatibility
- By increasing the performance- / cost-ratio, RCA provides incentives for ERTMS deployments

An open question is, how far on-going rollouts can prepare for a transition to an RCA-based architecture. Considerations for this are explained in the RCA Migration document. In the short run, using OC (object-controllers), based on EULYNX provides an RCA-compatible migration path for the trackside elements.

3.6 What are the interoperability effects of RCA?

Interoperability is covered by the ERTMS specifications in the TSI CCS. RCA does not fundamentally affect this. New features in RCA may of course result in change requests, which will then be appropriately dealt with

[5] For some background: see http://www.unife.org/component/attachments/attachments.html?id=785

in the ERA Change Control Management process, also taking into account backward and forward compatibility.

4 Migration

4.1 Are migration issues part of RCA?

Yes, migration is a central aspect of RCA. Several mechanisms in the architecture support migration. Examples of migration paths are part of the RCA documentation.

4.2 Will RCA require a certain migration strategy?

RCA analysed the current starting point of railways and designed a set of migration paths leading to the target architecture. This set of migration strategies can be used as a driver/requirement for the architecture. While RCA describes some migration “patterns”, each IM will have to choose their own specific migration strategy.

4.3 How do (on-going / planned) ETCS L2 rollout programs fit with RCA?

RCA provides an opportunity for on-going and planned ETCS L2 trackside implementations to consider a different solution with potentially greater benefits. RCA supports ETCS L2 functionality and interoperability with existing ETCS onboard systems. Further analysis is needed to understand what opportunities could exist in national rollout plans.

5 How to use RCA / Effects of using RCA for railways

5.1 Will the architecture lead to identical business processes among railways?

Not necessarily, see question “Will RCA harmonise business process of the railway companies?”

5.2 Will the architecture lead to identical equipment of the IMs?

No, the goal is standardisation / modularisation on important interfaces for the “building block”. So, firstly, the building block can be implemented by competing companies. Secondly, different railways may use different configurations / system designs of the building blocks.

5.3 How is the architecture going to have an impact “in the real world”?

Adopting RCA accelerates delivery through the re-use of effective requirements, solution and provides a basis for governance to ensure the consistency and applicability of technology (similar model to EULYNX). In the field of software, many empirical studies have shown the following common benefits and drawbacks from adopting a reference architecture: (a) improvement of the interoperability of the systems by establishing a standard solution and common mechanisms for information exchange; (b) reduction of the development costs of software projects through the reuse of common assets; (c) improvement of the communication because stakeholders share the same architectural mindset; and, (d) influencing the learning curve of developers due to the need of learning its features.

5.4 Who can use the RCA?

The specifications of RCA interfaces will be freely available, under EUPL or similar.

5.5 What is the impact for Railway Undertakings?

As is the case with today's ERTMS, CCS functionality is implemented in the vehicle in accordance with the CCS TSI. This means that Railway Undertakings will not be impacted by the use of RCA as this is about reconfiguration of the infrastructure elements of ERTMS without impacting interoperability. The high costs for implementation of ERTMS and the foreseen game changers in the vehicles will have to be tackled anyway. This is independent of RCA. Without better upgradability of the vehicles, ERTMS rollout will not be feasible. The initiative OCORA for a modular vehicle architecture was launched to reduce the costs of implementing / upgrading CCS functions on the vehicle.

In addition, mechanisms have to be agreed on, to make sure that both IM's and RU's benefit from RCA and OCORA. This is outside the technical scope of RCA.

6 Organisation of RCA processes

6.1 Who governs the RCA process?

Memorandum of Understanding between EUG and EULYNX provides a governance model. See https://ertms.be/workgroups/ccs_architecture. So, the governing bodies of RCA are EUG and EULYNX.

6.2 How committed are the IMs?

The RCA Whitepaper and MoU have been signed by the members of EULYNX and the ERTMS User Group, a total of 14 IMs. In the RCA strategy group and core group we have a total of 8 IMs as active contributors / participants. On 13.6.2019, during the European Infrastructure Manager Forum in Bern, DB, NR, and SBB have signed a declaration to orient their ongoing programs (Digitale Schiene Deutschland, Target190+, smartrail 4.0) to contribute to the development of RCA, to apply RCA in future ERTMS rollouts, and to keep an open and inclusive process.

6.3 What is the role of industry / suppliers in RCA?

As with the EULYNX initiative, RCA raises questions about the impact on the relation of railway (customers) and industry (suppliers). What does not change with RCA is that railways (IMs) will continue to need suppliers of CCS components and systems. What does change are the following elements:

- Railways harmonise requirements and define architecture. This leads to reduced variability in components;
- Exchangeable components. This leads to more competition and allows faster renewals;
- Smaller components (note: it's the buyer's decision how procurements bundle components). This may allow new market entrants and to the need for additional integration services;
- Separating of function (software) and box (runtime environment). This may allow new market entrants.
- The modularity and the upgradability of RCA may enable service models in the future i.e. IMs purchasing the services of a safe platform running in a data-centre.

The consequences of these changes must be understood and acted upon by both sides. This will need discussions and mutual feedback.

6.4 What is the impact on Sourcing / Procurement? The role of Integrator?

IMs can procure RCA components individually or bundled (i.e. integrated). When individual components are procured, a separate integration step is necessary. Integration service provider may be one of the suppliers or a third specialised party. We expect this integration step to be performed by an integration service provider. Even when buying bundled (integrated) components, IMs should specify all RCA-interfaces, to ensure future upgradability and to reduce vendor lock-in. This integration step is not totally new, since already today almost all suppliers will have to include third-parties equipment or interface to existing equipment.

6.5 Is RCA a "win-lose" proposition for railway industry?

The story of RCA is to increase the performance / TCO-ratio of our CCS systems. For some this is equivalent to "railways pay less – industry earns less". This is not the complete picture since standardised architectures make it possible to sell a single component in the same form in much more countries. So, the market for a single component gets much larger and the ROI of a development is better. But of course, this may lead to increased competition.

There are several upside potentials for industry:

- Better performance / TCO-ratio will make equipping / renewals attractive that are simply not economical today, this may lead to a bigger overall market;
- Reduction of development risks (market acceptance, product variability);
- Better evolvability may lead to more frequent renewals;

- Better overall performance / TCO of the railway system ensures customer money and public funds will be available in the long-term i.e. it is a key enabler for national programs and helps to release the funding, so it is a win / win situation for suppliers and railways.

7 Architectural decisions

7.1 Where is the interlocking (IXL) and RBC?

RCA defines a new structure (architecture) for the interlocking logic. To avoid confusion, a new name was chosen: the APS (advanced protection system) roughly covers the purpose of today's interlockings and the RBC i.e. the APS is combining ETCS procedures and processes with interlocking procedures and processes. The core of the protection logic has been assigned to the components named SL (safety logic) and SM (safety manager).

7.2 What is a "geometric interlocking? Why is it needed?

RCA uses the term APS (advanced protection system) for a collection of components ensuring safe operations. An APS is a "geometrically working interlocking" in which the functions of interlocking and RBC (Radio Block Centre) are completely merged. It has been specifically designed for radio-based ETCS cab signalling. The concepts "route" (from traditional interlocking) and "movement authority" (RBC) are merged into a single "movement permission", which is purely geometrically defined (offsets on the segments of the network) and no longer uses pre-defined sections. The APS can combine train localisation information from different sources, including ETCS train position reports, block-oriented train-detection devices and others.

Simplified: An APS is an "ETCS L3-compatible RBC, which also controls moveable elements for a movement permission".

This reduces complexity, allows data-driven engineering work, sets free additional capacity especially in nodes, supports mixed (localisation) modes, allow re-using the existing track layouts and removes the dependency from technology dependent signalling principles.

7.3 Why does RCA plan for largely centralised trackside systems?

The TMS and APS (Interlocking) seem to be centralised in RCA, why not plan for totally decentralised (swarm) intelligence on the vehicles?

Vehicles are going to be more "intelligent" with RCA. Functions such as (Auto-)localisation and ATO will simplify the trackside and put more requirements on the vehicles (a process already started with ETCS L1 and L2). Complete distribution of the logic for planning, dispatching, and controlling trains (and omitting all centralised / trackside logic) is not sound from an engineering point of view:

- Safe movements of trains are only possible with knowledge of movements of other trains, other track occupations, and allocation (locking) of switches. While in principle a distributed system (with each train being a decentralised datacentre) is possible, it would be an order of magnitude more complex than using a centralised, "single point of truth";
- The scarce resource is in many cases the physical track. Only logic covering a large part of the network (knowing the state and plan for trains and able to control them) will be able to optimise this scarce resource, especially since overtaking of trains cannot be performed everywhere and deadlocks have to be avoided;
- The interaction with RUs (vehicle and personnel planning) and customers (traffic information) will need centralised hubs anyway;
- The central approach helps to make decisions based on the prediction of impact for the full network instead of local optimisation.

7.4 Why are the components in RCA so granular?

Key RCA principles is to define largest possible components whilst providing IMs flexibility and choice. Components have only been divided if required by one of the splitting rules (e.g. separating safe and non-safe functions or separating functions with very different requirements for update). Nevertheless, the RCA components are not cast in stone. If a component separation stops making sense, we will merge the components.

7.5 Will this level of standardisation hamper innovation?

“Bad” standards can reduce innovation, “good” standards can drive innovation (example Bluetooth Connect driving innovation and creating a new market see - https://www.bluetooth.com/blog/celebrating-20-years-of-market-creation). The design rules of RCA are explicitly oriented towards upgradability which is a prerequisite for innovation in a complex system. Some of the important characteristics of RCA include:

- Focusing on interfaces and not specific implementations.
- Applying the well-known automation pyramid for decoupled layers.
- Applying capability-based protocols; strictly separating protocol layers (“carrier independence”).
- etc.

We are confident, that against the backdrop of a strong reference architecture such as RCA, the innovation rate will be higher than today.

7.6 What is the role of platform independence in the RCA?

In addition to the “logical” decomposition of functions into components, RCA plans to specify a platform (run-time environment and communication stack) on which the logical components can be executed. The logical components can become pure software which will increase the options for “mix-and-match” of components, for virtualisation, co-location, even cloud-based models. A software application using a safe and proven cloud based environment provides not just hardware abstraction, but a platform independent virtualised runtime environment.

7.7 What is modular safety?

Modular safety is a design goal of RCA, to reduce the overall safety case workload by using modularity not only for the technical design of components, but also to use modularity to foster independent, re-usable, composable safety cases. Overall it means to reduce the workload of the impact analysis for changes and end2end corrections to a possible minimum. The concept is based on the CENELEC concepts of processes for generic product, generic application, specific application and is under development.