# RCA – FAQ (frequently asked questions)

# 1. Goals and direction

## 1.1. What is RCA?

RCA (= reference CCS[1] architecture) is an initiative by the members of EUG[2] and EULYNX to define a harmonized architecture for the future railway CCS, with the main goal to substantially increase the performance / TCO[3] ratio of CCS in comparison with today's implementations.

## 1.2. Why RCA?

The reasons and main background for the RCA initiative are explained in the RCA white paper, accessible here: https://ertms.be/workgroups/ccs_architecture and here: https://www.eulynx.eu/index.php/home2/37-reference-ccs-architecture-white-paper.

## 1.3. How will RCA help?

RCA:

- defines standardized, evolvable interfaces for all major components of the future railway CCS;
- defines a clean target architecture without legacy systems, while providing a migration path[4];
- brings in new technology and ensures that technological progress from other sectors reaches the railways.

RCA helps IM achieve the following goals[5]:

- 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.

## 1.4. What is the status of RCA?

Versions Alpha and Beta are early concepts of RCA, and therefore not yet complete and precise specifications,

**Version Alpha (15.2.2019)**

The version RCA Alpha is the result of iteration 0 on the RCA performed by the RCA group in the second half of 2018 and provides a first, high-level draft of the RCA called release "alpha". RCA Alpha provides a starting point for:

- achieving the next level of understanding and commitment by the EUG and EULYNX members concerning RCA;
- organizing the next steps in the RCA development process involving several working groups;
- continuing the discussion, allowing feedback, providing guidance with other stakeholders (industry, regulators, owners).

**Version Beta (26.8.2019)**

RCA Beta is an update of RCA Alpha taking into account feedback from RCA Alpha (from railways, suppliers, sector organizations). RCA Beta mostly deals with corrections, misunderstandings and frequently asked questions. RCA Beta is released in the form of an updated set of documents from RCA Alpha with a few additional "Beta chapters" on topics which have generated a lot of interest.

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[1] CCS = command, control & signalling

[2] EUG = ERTMS Users Group

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

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

[5] 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.

## 1.5. Will RCA fully harmonize 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 consider generic harmonized 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 harmonization of business processes resulting from using the same “building-blocks”. Full harmonization is not required however, as long as interoperability is ensured.

Harmonization 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.

## 1.6. Is ATO in scope of the RCA?

Yes, RCA includes (but does not absolutely require) ATO. Different RCA target configurations will support GoA1, GoA2, and GoA3 / GoA4.

## 1.7. Are vehicles in scope of the RCA?

The component architecture of the vehicles with EVC, ATO, Localization, etc. is part of the overall CCS architecture the railway system must solve. So, 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.

## 1.8. 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.

## 1.9. Is a traffic management system (TMS) in the scope of RCA?

A TMS typically has several functional blocks, including:

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

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

## 1.10. What is the deliverable of RCA?

The main deliverable is a set of interface specifications for the defined RCA subsystems. These specifications can be used as tender templates for companies (IMs) building / procuring an RCA-based system. The specifications should therefore lead to a larger market for a given product.
Additional deliverables include supporting material for IVV (Integration, Verification, Validation) of the RCA subsystems. Also, part of RCA is material helping to plan for an RCA-based system (such as business case mechanics, supported target architectures, etc.) and material helping to understand the decomposition of the RCA subsystems.

## 1.11. 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. Maybe a formal standard for RCA may be helpful at a later time.

## 1.12. 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 standardization for interoperability. There are several areas (not relevant for interoperability) where the railways would benefit from stronger harmonization of their equipment / components. RCA addresses some of these areas, based on a coherent overall architecture.

## 1.13. 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 optimization 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.

## 1.14. What is the relation between RCA and EULYNX?

RCA and EULYNX are coordinated and related in several ways:

- The EULYNX organization is (together with EUG) one of the governing bodies of RCA.
- The principle of railway companies harmonizing requirements to define standardized 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.

## 1.15. What is the relation with well-known "digital" railway programmes?

Several railways have announced / started substantial modernization 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 harmonized development of RCA and to base these programs on RCA. On 13.6.2019, the 3 programmes have signed a joint declaration of intent to that effect.

# 2. Target architecture

## 2.1. What is the foundation of the target architecture of RCA?

RCA is radio-based ERTMS/ETCS cab-signalling including all elements needed for this.

## 2.2. 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 localization, 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.

## 2.3. Does RCA include ERTMS "game changers"?

Yes, some of the game-changers frequently mentioned[6] are: automatic train operation,
full moving block, train-borne localization (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 localization no particular technology (i.e.

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

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 optimize braking curves in the future.

## 2.4. Is there only one target architecture for RCA?

No, RCA-based system can choose different functional target configurations, without jeopardizing interoperability. Possible variants in target architecture include: ATO (none – GoA2 - GoA3 – GoA4), the choice / mix of localization technology, physical deployment (centralization / regionalization), 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.

## 2.5. How are needs for innovation and for stability balanced in RCA?

An MoU between ERA and different stakeholders describes the need for stability in the ERTMS specification. At the same time, it is clear that the sector needs innovation and that the current form of implementation of CCS can (and must) be improved. RCA on one hand brings a push for innovation[7] and brings in changes. But these changes happen in the technologies and used products, while in the TSI CCS only smaller changes are necessary. The focus on well-defined, evolvable interfaces will help stabilize the system, by making changes more local (limited impact) or by allowing fast upgrades (reducing complexity).

## 2.6. 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. This will be elaborated in the future. In the short run, using OC (object-controllers), based on EULYNX provides an RCA-compatible migration path for the trackside elements.

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

# 3. Migration

## 3.1. 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.

[7] innovations include for example localization technology or the degree of automation (not only for driving) but also for planning, command & control.

## 3.2. Will RCA require a certain migration strategy?

RCA will analyse the current starting point of railways and design a small set of migration paths leading to the target architecture. This set of migration strategies will 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.

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

Not only are today’s ETCS L2 implementation limited in their performance/TCO-ratio, more importantly they are not easy to evolve. Therefore, the RCA is deemed time critical, the earlier the new (RCA based) ERTMS implementations are available the sooner we have systems installed that can be easily adapted and grown cost effectively.

# 4. How to use RCA / Effects of using RCA for railways

## 4.1. Will the architecture lead to identical business processes among railways?

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

## 4.2. Will the architecture lead to identical equipment of the IMs?

No, the goal is standardization / modularization 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.

## 4.3. How is the architecture going to have an impact “in the real world”?

To have an effect, the architecture and its specifications must become a requirement in tenders from the IMs (same model as EULYNX).

## 4.4. Who can use the RCA?

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

## 4.5. When can I use RCA?

For IMs: You can prepare a business case and IM-internal lobbying for an RCA-based system now.
For RUs: you can get information on the initiative regarding vehicle architecture (OCORA) and decide if you want to participate.
For Suppliers: you can provide feedback to the architecture and start planning technical demonstrators and adaptions to your product line now.

## 4.6. 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 re-configuration 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.

# 5. How to contribute to RCA

## 5.1. Who can contribute to RCA?

Anybody (IM, S2R, supplier, researcher….) can contribute a specification or concept to the RCA.

## 5.2. Are there any rules for RCA contributions?

To be included in the RCA, proposals will go through a formal Change control board (CCB). Important requirements for contributions are (in addition of an overall fit with the architecture):

- interface specifications to a level of precision to allow exchangeable components;
- interfaces designed to maximize upward-compatibility;
- interface specifications free of IPR that may be an obstacle to the exchangeability or upgradability of components (products or component implementations may, of course, still be protected by IPR).

# 6. Organization of RCA processes

## 6.1. Who governs the RCA process?

RCA was started by a white paper and Memorandum of Understanding between EUG and EULYNX. See https://ertms.be/workgroups/ccs_architecture. So, the governing bodies of RCA are EUG and EULYNX.

## 6.2. What is the relation of RCA to TSI processes?

ERTMS is a key component of the RCA, as such interoperability is required. Any relevant changes identified as part of this work (RCA), will be fed back into the existing change request process. This is expected to be achieved through a separate paper to give an overview, justify the CRs and explain their relation to help with the process. This may include trials to validate via practical experience.
The modular architecture of RCA can be realized with today's ETCS specs. There are areas of improvement which will be addressed by raising CRs. We try to limit the amount of changes needed on ETCS since every change is difficult and costly.

## 6.3. 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.

## 6.4. What is the relation of RCA to Shift2Rail?

RCA is harmonizing architectural user requirements for the future railway system as a stable basis for industrial developments. It is led by the Infrastructure Managers who are members of the ERTMS Users Group and EULYNX. Shift2rail is “the first European rail initiative to seek focused research and innovation (R&I) and market-driven solutions by accelerating the integration of new and advanced technologies into innovative rail product solutions”. We plan to have substantial interactions between RCA and Shift2Rail. In particular, RCA will provide inputs to the S2R strategy and architecture work (a S2R project on railway system architecture starts in 2019), and S2R may contribute with specification work and demonstrators to RCA. Many members of the ERTMS Users Group and EULYNX are also Founding Member or Associated Member of Shift2Rail and require RCA and the work in Shift2Rail to be aligned.

## 6.5. 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 harmonize 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. A current proposal in S2R (Linx4rail) sets out to study the business case perspective for supplier.

## 6.6. 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 specialized 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.

## 6.7. 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 standardized 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.

## 6.8. How can suppliers be "in the loop"?

RCA was initiated by IMs. It is clear that good solutions will need the active involvement of suppliers. Already today we include in RCA existing interfaces such as ETCS or ATO-over-ETCS. We plan to adapt our current governance to include more feedback from suppliers.

EULYNX and UNIFE are finalising an agreement on a cooperation model to strengthen the involvement of suppliers. The cooperation model would actively involve UNIFE representatives in the development of specifications and in the change control process. We expect to extend such a cooperation model also to RCA development.

## 6.9. Risks: what could go wrong?

The white paper contains a description of the most important risks regarding the success of the RCA initiative. The list includes: 1. Disagreement between members. 2. Challenge on Life Cycle Cost (LCC) reductions. 3. Lack of resources to do the work. 4. Lack of funding. 5. Opposition from Railway Undertakings. 6. Lack of support of suppliers. 7. Lack of support at EU level. 8. Delay of national ERTMS roll out projects. 9. RCA will be too late.

# 7. Architectural decisions

## 7.1. Where is the interlocking (IXL)?

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 localization 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 (localization) 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 centralized trackside systems?

*The TMS and APS (Interlocking) seem to be centralized in RCA, why not plan for totally decentralized (swarm) intelligence on the vehicles?*
Vehicles are going to be more "intelligent" with RCA. Functions such as (Auto-)localization 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 centralized / 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 decentralized datacentre) is possible, it would be an order of magnitude more complex than using a centralized, "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 optimize 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 centralized hubs anyway;
- The central approach helps to make decisions based on the prediction of impact for the full network instead of local optimization.

## 7.4. Why are the components in RCA so granular?

The components in RCA have actually been kept quite large. 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 standardization hamper innovation?

“Bad” standards can reduce innovation, “good” standards can drive innovation. 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 virtualization, co-location, even cloud-based models. This is the standard model in IT and, increasingly, automotive. Of course, this also requires a mature concept for “modular safety”.

## 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.