18C044-0C WHITE PAPER REFERENCE CCS ARCHITECTURE BASED ON ERTMS

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Introduction

In 1989, the European Union, together with the railway organisations, decided to develop a standard European System (Class A) for Automatic Train Protection (ATP) to replace a patchwork of 24 different national (Class B) ATP systems: The European Rail Traffic Management System (ERTMS). The goals of ERTMS were: 1) Increase of safety (compared to most of the Class B systems), 2) interoperability (to allow the free flow of trains all over Europe), 3) Increase of capacity and 4) reduction of costs.

It took more than 25 years to define ERTMS in such a way that it would satisfy the initial needs of the different railway organisations. Today, the specifications of ERTMS are mature enough to start the large-scale implementation of ERTMS.

The members of the ERTMS Users Group (EUG), large railway organisations with substantial investments in ERTMS (more than € 250 million each), recognise that the implementation of ERTMS is complex due to the differences in design of their railway networks, the dependency between train operating companies and infrastructure managers and the large investments to be made with only long-term return of investment. They also recognise that, even though ERTMS can now be implemented on their network, they will not be able to reap the full benefits of lower costs and improved capacity if they keep the design, operation and management of their networks based on and in combination with the legacy Command and Control Systems (CCS).

Attempts to harmonise the interlocking part of CCS in Europe have been made in the past (Euro Interlocking, INESS), but did not provide a clear business case. A different approach is focusing on reduction of life cycle costs due to the interchangeability of components (opening of the market). This has resulted in a set of interface specifications for the trackside part of the CCS, developed under the umbrella of EULYNX.

Now that ERTMS is mature enough and ready for large scale deployment, both members of EUG and EULYNX believe that it is the right moment to try to define a common, simple reference CCS architecture to support the step from installed base to ERTMS and to increase the capacity of the existing network, improve the deployment speed and reduce life cycle costs for CCS.

The Reference CCS Architecture (RCA), developed using formalised methods, is the enabler for clear and unambiguous interface definitions. It is aimed to provide generic safety approvals (plug & play), a modular split of work, independent development of components (allowing for technical evolution), an important quality step in the specification of operators' needs towards the supply industry and the strengthening of this supply industry.

Cost drivers for CCS are data collection and validation, procurement, design, installation and commissioning, operation, maintenance and change management. RCA is expected to reduce costs within all these areas.

Characteristics of a Reference CCS Architecture

- The RCA is a basic structure of components and interfaces, that are chosen from existing standards (preferably stable industry standards or TSI protocol) or are defined with additional specifications, if no relevant standard exists.
- The scope of the RCA is the core functionality and interfaces of the trackside safety part of the CCS system. The CCS components outside the trackside safety part will be taken into account as far as relevant in order to define the interfaces with these components, with a view on CCS as a whole.
- The starting point and the foundation for the RCA development is the following:
  - The ERTMS specifications as defined in the TSI CCS
  - The EULYNX specifications defined by the EULYNX consortium
- The RCA target picture consists of radio based ETCS cab signalling including all elements needed for this.
- New technologies and developments, e.g. the European Union Agency for Railways (ERA) game changers (ATO, Level 3, Future Communication System, Satellite Positioning, ...), will be taken into account.
- The main targets and quality attributes of the RCA are
  - "**Low LCC":** The RCA shall allow the implementation and operation of a trackside CCS with a low number of standardised system components (simplified architecture), with the ability to procure these standardised system components in a competitive market with automated processes (this requires integrated data management);
  - "**A single modular framework**": The RCA shall specify the generic design of trackside CCS with ability to elect configurations within the modular framework to facilitate migration strategies and adaptations to specific business challenges;
  - "**Migratability**": Low cost solutions for interfacing to existing systems in the environment around the RCA, protecting existing investments;
  - "**Adaptability**": The RCA shall be a generic design, allowing different levels of requirements concerning safety, costs/LCC, availability, performance and other non-functional requirements by configurational parameters or component selection (plug& play). Software/ hardware adaptions of the individual components are to be avoided;
  - "**Safe Investment**": The interface quality of the RCA (in general Form, Fit, Functional Interface Specifications - FFFIS) shall aim to avoid incompatibilities to future developments by using well prepared mechanisms for upwards and downwards compatibility. Interfaces shall be defined on a formalized basis (and with real and early prepared reference systems for testing) for all communication layers to avoid vendor specific deviations.

Business case

To achieve reductions in life cycle costs the RCA shall facilitate:

- Significant reductions in the number and types of trackside assets;
- Optimisation of operational processes;
- Implementation of the game changers;

- Standardised and automated data preparation for open engineering and testing;
- Cost effective implementation and maintenance features for every interface and component (e.g. simple integration safety case by an automated impact analysis, remote updateability);
- Competitive procurement based on exchangeability of components;
- Open specification, standardised interfaces and use of mature industry standards;
- Components allowing independent industrial developments and deployments in a whole infrastructure or fleet ('components of the shelf').

To understand the potential whole life cost savings for the RCA, an initial review of available business case methodology for such an approach was carried out. Whilst it may not reflect the final RCA opportunities and may not be directly appropriate for all countries, the available SBB business model calculation methodology was considered the most appropriate for early stage LCC analysis. For their own network, SBB estimates the potential LCC reduction from its SmartRail 4.0 programme which has similar objectives to the RCA to be around € 375 million per year. Extrapolation of the business model calculation methodology of SBB to the other members[1], reveals a significant LCC reduction.

Even though this RCA strategy focusses on the trackside primarily, LCC reductions for new fleets are also possible when due consideration is given to the on-board CCS architecture (this is outside the present scope).

Although each member could pursue its own RCA strategy, it is evident that significant (additional) costs savings can be reached by collaboration. Firstly, because this means sharing of resources to define the architecture. Secondly, because harmonised requirements will lead to economies of scale for Infrastructure Managers and suppliers, which will in turn lead to increased competition over all life cycle aspects, better return on investment for developments (shorter time to market/standardisation) and lower prices.

Migration and roadmap

The future RCA is based on radio communication between ETCS train borne and trackside subsystems without lineside signals. This approach negates the need to consider legacy system issues apart from the geographic interfaces to existing conventional systems which are typically well understood. To facilitate this approach all rolling stock running over lines based on the RCA approach will need to have the radio based ETCS capability prior to the implementation of trackside systems.

The RCA shall allow flexible migration plans (fast versus slow, pure or "mixed" situations) without offending the "single modular framework" (e.g. by using hardware abstraction layers, adaptable communication layers or adaptable context-based protocols). The migration approach might be different per Infrastructure Manager.

To be able to develop a migration strategy for CCS, the future target system architecture has to be described within the framework to a certain level first. This includes high level decomposition of the RCA into building blocks. Due consideration will be given to safety and security (including cyber security).

[1] Except BaneNOR and Banedanmark, which are already embarked on overall CCS renewal projects.

After this initial phase, the roadmap shall consist of the following elements:

- Functional requirements specifications of the different building blocks, recognising work already done
- System requirements specifications of the different building blocks, recognising work already done
- Functional Interface Specifications between the different building blocks, if needed followed by FFFIS, recognising work already done and if possible making use of industrial standards
- Data model with standardised and automated data preparation processes for open engineering and testing
- Analysis of migration scenarios and provision of solutions for members
- Determination of the future procurement volume and timing for supply industry
- Early implementation projects and evaluation of results for feedback
- Publication and dissemination of specifications (in tranches)
- Deployment.

Some of the elements of the roadmap can take place simultaneously.

Organisation

The Reference CCS Architecture will be developed by the collaboration of the Infrastructure Managers through the EUG and EULYNX[2].

Risks

The following risks and their mitigations are identified:

1. **Disagreement between members:** One of the major risks is disagreement among EUG Members/Associate Members and/or EULYNX Members about the architecture, resulting in loss of time. Such disagreement will be detected through the RCA collaboration. As soon as it is clear that no internal solution can be found, the disagreement will be escalated to the EUG General Assembly (after consultation of the EUG NPM Committee) and/or the EULYNX Steering Committee who will make a decision in accordance with their Statutes and Internal Regulations.
2. **Challenge on Life Cycle Cost (LCC) reductions:** The possible LCC reductions highlighted in this paper are based on the methodology used by SBB within their SmartRail 4.0 development programme. This was considered to be the most developed LCC model that is aiming towards the objectives of the RCA initiative. Whilst this may be challengeable at this early stage, as it is not possible to say that RCA and SmartRail 4.0 are exactly aligned and some Infrastructure Managers may not adopt of the features of the RCA 'single modular framework', the possible LCC reductions are significant. As the programme develops an RCA LCC business case methodology shall be developed allowing refinement of the business case.

[2] A Memorandum of Understanding for the standardisation of interfaces and CCS architecture has been signed between EULYNX and EUG. The scope of this MoU includes the alignment and combination of the development for the future CCS architecture, including migration and controlled evolution.

3. **Lack of resources to do the work:** to mitigate this risk, activities will only be approved on the basis of sound resource planning and commitment of the members of EUG and EULYNX to allocate these resources, including financial commitment to hire external expertise if needed. The decision to hire external expertise shall be taken prior to executing and shall be in accordance with the guidelines of EUG and EULYNX.
4. **Lack of funding:** as mentioned above, the development of the RCA will be financed by EUG and EULYNX. The management of both organisations will prepare a multi-annual cost estimate for their organisation, which is to be covered by membership fees. Financing third parties, prototypes and implementation projects will be arranged by the interested members on a case by case basis. No projects will be started without prior internal agreement of EUG/EULYNX members and assurance of financing.
5. **Opposition from Railway Undertakings:** to mitigate this risk, there shall be collaboration with representatives of RUs on this RCA initiative, they form a key role in the supporting simplified CCS functionality and the need for train fitment and driver competence.
6. **Lack of support of suppliers:** to mitigate this risk, there shall be collaboration with suppliers on the RCA initiative and suppliers will be invited to contribute to the activities in various ways (e.g. reviewing functional and requirements specifications, preparing technical specifications and advising on technical solutions). However, leadership of the RCA development will remain in the hands of the EUG/EULYNX members at all times.
7. **Lack of support at EU level (DG MOVE/ERA/S2R and CER/EIM/EPTTOLA/ERFA):** these organisations are essential for the success of the RCA initiative. DG MOVE, ERA and S2R will be instrumental in the progress of the RCA. Alignment and coordination with ERA and S2R activities will be sought. All other EU organisations will be consulted and kept fully informed in a transparent manner.
8. **Delay of national ERTMS roll out projects:** Decision makers might decide to wait for the RCA outcome before starting ERTMS roll out. This may ultimately delay the ERTMS deployment in Europe. This is a consideration for each of the individual infrastructure managers to take into account when designing their national migration strategy. The risk can be mitigated by keeping pressure on the rapid development of the RCA and that the RCA is aligned with the direction set out in the above section “Characteristics of a Reference CCS Architecture”.
9. **RCA will be too late:** for some members, renewal projects will start before RCA can deliver ‘proven technology’. Again, this risk can be mitigated by keeping pressure on the rapid development of the RCA. And it is part of the individual migration strategies. Such strategies could include the option to embark on proven solutions in a later phase. The RCA will be easily migratable by following the directions set out in the above section “Characteristics of a Reference CCS Architecture”.