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ERTMS/ETCS

Concept for the evolution of the on-board CCS architecture

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3. TERMS & DEFINITIONS

Term	Definition
API	Application Programming Interface
ASTP	Advanced Safe Train Positioning
ATO	Automatic Train Operation
BDC	Basic Design Characteristics
CCM	Change Control Management In this document CCM means the process of updating the specifications created in relation to the on-board CCS architecture (e.g. the ETCS system specification Subset-026).
CCS	Control, Command and Signaling CCS means the subsystems on-board CCS and trackside CCS as defined in the EU directive 2016/797 and described in the technical specifications for interoperability for the control, command and signaling subsystems.
CEIA	Comparative Economic Impact Assessment
CFM	Communication Functional Module
Consist	Term from IEC61375. Wagon/locomotive ('Vehicle') or set of wagons which are not to be separated for operational purposes (during passenger or transport service) (even if this would be technically possible). As a rule, a Consist has a single Consist Network.
Consist-local communication	Communication that is limited to a single consist.
Deviation	Non-implemented or wrongly implemented requirement (e.g. according to a specification as referenced in the [CCS TSI]) in a subsystem. The non-implementation is not done on purpose (e.g. software error) and not indicated in the validation or in the certificates of the subsystem at the time of validation or certification of the subsystem.
ECN	Ethernet Consist Network as per IEC 61375-3-4
EDOR	ETCS on-board Data Only Radio
ER	Euroradio
ERJU	Europe's Rail Joint Undertaking
ERG	Euroradio Gateway
ESC	ETCS System Compatibility
ETCS	European Train Control System
Exchangeability	Ability to replace a subsystem from supplier A by a subsystem from supplier B without affecting other subsystems or the overall system/subsystem and with a reasonable integration effort and/or certification effort.

Term	Definition
FFFIS	Form Fit Functional Interface Specification
FIS	Functional Interface Specification
FRMCS	Future Railway Mobile Communication System
FRS	Functional Requirements Specification
Functional Building Block	A functional building block is a fully functional product such as interoperability constituents (ETCS on-board, ATO on-board) or national train control systems.
HW	Hardware
IC	Interoperability Constituent
Interchangeability	Ability to replace a subsystem from supplier A by a subsystem from supplier B without affecting other subsystem or the overall system/subsystem and with a lowest reasonable integration effort and without any need for recertification (plug and play).
Interoperability constituent	See Directive (EU) 2016/797, Article 2 (7). Addition: Every interoperability constituent of the on-board CCS subsystem shall be a subsystem with restrictions on implementation through • a FFFIS interface to the trackside CCS subsystem or • requirements on functional behavior relevant for harmonized interoperable operation • or both. Subsystems without these restrictions on implementation must not be defined as interoperability constituents but may be regarded as exchangeable subsystems.
IP	ERJU Innovation Pillar
Logical component	An abstraction of a system that performs the system functions without imposing restrictions on implementation. Logical components are also only connected via FIS and not via FFFIS interfaces.
LRBG	Last Relevant Balise Group
MDS	Multi Display System
NTP	Network Time Protocol
OMS	Online Monitoring System
OSI	Open Systems Interconnection
Partial fulfillment	Non-implementation of a functionality which is mandatory according to the specification (e.g. a specification as referenced in the [CCS TSI]) in a subsystem. The non-implementation is done on purpose (e.g. by the manufacturer) and indicated in the validation or in the certificates of the subsystem.
Process data	Small amount of data, representing a single value of a control application. Typically distributed in a cyclic manner.

Term	Definition
Realtime data	Data that needs to be communicated within a certain upper time limit.
RPC	Remote Procedure Call
SFM	Safety Functional Module
SP	ERJU System Pillar
Subsystem	The term subsystem is used in this document for two purposes. 1. See Directive (EU) 2016/797, Article 2 (5). If the term is used for this purpose, it is always phrased as either a. "on-board CCS subsystem", i.e. the on-board CCS subsystem as defined in Regulation (EU) 2023/1695; b. “trackside CCS subsystem”, i.e. the trackside CCS subsystem as defined in Regulation (EU) 2023/1695; c. “Rolling Stock subsystem”, i.e. the Rolling Stock subsystem as defined per Directive (EU) 2016/797. 2. An abstraction of a system that performs the system functions or parts of them with imposing restrictions on implementation, sometimes also defined as physical components. Subsystems are connected via FFFIS interfaces. Subsystems can be interchangeable, exchangeable or an interoperability constituent.
SV	ETCS System Version
SW	Software
TCMS	Train Control and Management System
TON	Train Operator Network
TOS	Train Operator System
Train-local	Communication limited to a vehicle, not communicated to the landside
Zone	Logical part of the on-train system architecture. In alignment with the security concepts the typical zones are: FRMCS, CCS, TCMS, TOS, Passenger Network

4. SCOPE

4.1.1.1 This document describes the UNISIG considerations on the evolution of the on-board CCS subsystem as defined by the CCS TSI in close collaboration with UNIFE members from vehicle manufacturers and UNITEL.

4.1.1.2 It considers

- Automatic train protection (ETCS and national train control);
- Automatic train operation;
- CCS related aspects of the driver machine interface;
- CCS related aspects of radio communication (ETCS/ATO data radio and voice cab radio → other radio functionality is outside the scope of this document));
- Interfaces of the on-board CCS subsystem to the
  - trackside CCS subsystem
  - rolling stock subsystem (incl. TCMS and juridical recording)

  and the related integration aspects among these interfaces (incl. the creation of a specification for a future common communication bus among all functional building blocks of the on-board CCS architecture (Ethernet CCS Consist Network)).

4.1.1.3 The level of abstraction for the on-board CCS subsystem as proposed by this document is mainly based on subsystems and logical components.

4.1.1.4 Subsystems are determined only by requirements necessary for interoperability and exchangeability, meaning functional requirements (for operational compatibility) and FFFIS specifications (for technical compatibility).

4.1.1.5 Other restrictions for the design of a subsystem will not be taken into account, because they can be defined under the sole responsibility of the supplier.

4.1.1.6 According to [SP Granularity Principles] the objectives of interchangeability and exchangeability are described in the following way:

- Objective of exchangeability is to ease integration; exchange subsystems from different suppliers with only a reasonable integration and/or certification effort.
- Objective of interchangeability is to exchange subsystems from different suppliers in already certified installations with the lowest reasonable integration effort.

4.1.1.7 In the context of the on-board CCS subsystem, an integration and/or certification effort is always necessary and achieving plug-and-play functionality with an acceptable level

of effort is not feasible according to UNISIG-internal analysis. From these objectives it is evident that the realistic level of harmonization to be achieved is “exchangeability“.

4.1.1.8 Therefore, interchangeability among suppliers’ subsystems (safe computing platforms, middleware, antennas etc.) is out of scope as economically not justifiable and regarded as an obstacle for innovation. It will not be considered further in this document.

4.1.1.9 Logical components are used if only a functionality must be considered for operational compatibility, independent from the design. A logical component can then be implemented in a subsystem at the discretion of the supplier.

4.1.1.10 Figure 1 shows an abstraction of exchangeable subsystems.

4.1.1.11 The concept is designed to efficiently enhance the on-board CCS subsystem by creating a transparent platform for the communication (Ethernet CCS Consist Network), which allows an open interface to the core of the on-board CCS subsystem, the ETCS on-board. Easier manageable integration will be an additional positive side-effect of this approach.

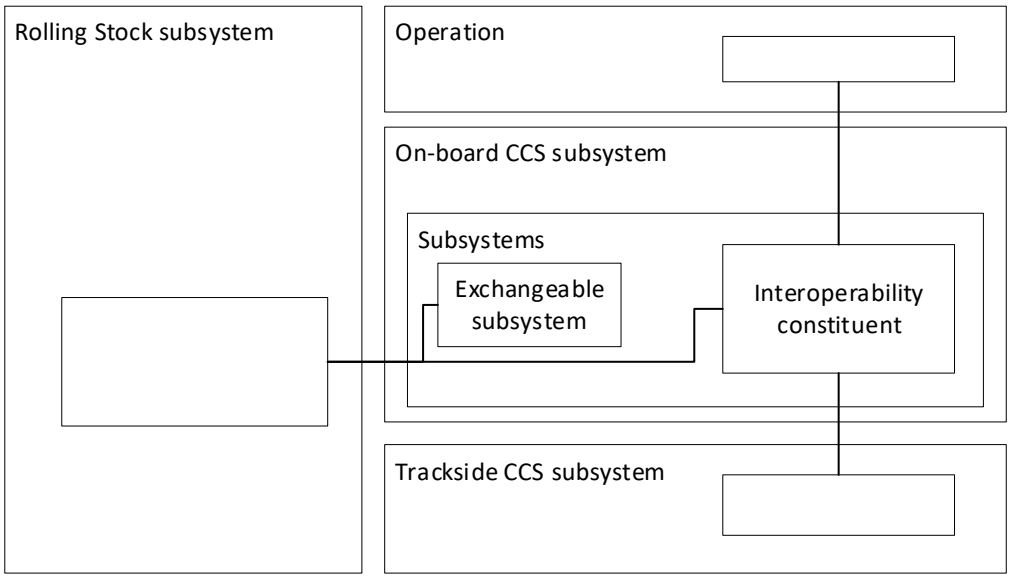

Figure 1 - Abstraction of exchangeable subsystems and interoperability constituents

4.1.1.12 The concept does not propose whether it will be applicable to new or existing vehicles (retrofit). As a rule, it is expected that requirements internal to the on-board CCS subsystem (requirements related to internal interfaces, requirements related to the communication with the trackside CCS subsystem) are mandatory also for existing vehicles, whereas requirements external to the on-board CCS subsystem (requirements related to the communication to the rolling stock subsystem) are applicable for new vehicle types only.

4.1.1.13 UNISIG prepared the document in the principle of “evolution instead of revolution,” particularly to ensure maximum forward and backward compatibility.

5. GUIDING PRINCIPLES

5.1 Introduction

5.1.1.1 Two of the European railway sector's goals concerning the on-board CCS subsystem are

- protection of investment and
- an adaptable approach to deal with system upgrades.

5.1.1.2 This can be achieved with better on-board CCS upgradeability and a simplification of system integration to be able to ease the integration of new subsystems from different vendors, facilitated by full standardization of most of the interfaces between subsystems within the on-board CCS subsystem and between the on-board CCS subsystem and its external environment (e.g. the Rolling Stock subsystem) and stability of the resulting standards.

5.1.1.3 Stability can be achieved by following the principle of decoupling, encapsulation resulting in simple and lean interfaces.

5.1.1.4 UNISIG analysed the railway sector's goals and derived guiding principles under which conditions these goals can be achieved. The guiding principles are the following:

- Game Changers;
- Modularity;
- Commitment towards ECN;
- Scalability;
- Migration strategy;
- Suggestions on the legal framework.

5.2 Game Changers

5.2.1.1 The game changers which have a direct impact on the design of the on-board CCS architecture are:

- FRMCS,
- ATO up to GoA4 and
- ETCS Hybrid Train Detection / Moving Block - Train Integrity.

5.3 Modularity

5.3.1.1 The achievement of the railway sector's goal as per 5.1.1.1 would require full standardisation of the layers (OSI layer 1 to 7) of the interfaces between subsystems, which can be exchangeable subsystems or interoperability constituents.

5.3.1.2 Manageable integration comes along with modularity, i.e. the separation of logical components of the on-board architecture, their independent specification and complete definition of the interfaces of their environment in order to become subsystems. Methods shall be put in place to make sure that the new subsystem undergoes the same quality assurance as the existing one, even if it is provided by different vendors.

5.3.1.3 Modularity is a parameter of the system design. It allows to break the complex system into fewer complex logical components or subsystems.

5.3.1.4 The individual logical components or subsystems can be more easily manageable as their functional perimeter is specifically defined. Furthermore, separating logical components or subsystems based on their higher-order characteristics, such as safety-related or non-safety-related, would enable a more efficient differentiation of design, verification, validation, certification and authorisation methods.

5.3.1.5 However, the greater the number of logical components or subsystems, the more complex the interfaces become. As the number of subsystems increases, so does the number of interfaces and the complexity.

5.3.1.6 Complexity also increases in case a functionality split does not follow principles of encapsulation and allocation. Too many subsystems might compromise clear structure and allocation of functionality. With increase of the number of subsystems the integration effort will excessively grow. If a function changes, the certification of functions that coexist with the modified function might then be impacted.

5.3.1.7 In addition, many conditions can arise through the interactions of the subsystems, which might not be fully understood when the logical component or subsystem and their related interfaces are being specified.

5.3.1.8 Furthermore, the responsibility of the system integrator for ensuring the safe integration of a specific application increases as the number of subsystems grows, particularly when these subsystems are sourced from different vendors. Today, the role of a system integrator remains undefined, which will lead to uncertainty about the overall responsibility.

5.3.1.9 Also, higher modularity may increase asynchronous evolution, where one subsystem changes without the related necessary changes in other subsystems. Changes to subsystems shall be carefully designed, but considerations of their effects on other subsystems of the system may be neglected or inadequate.

5.3.1.10 Asynchronous evolution can be mitigated by adequate documentation of constraints, conditions and assumptions and by checking before changes are performed to determine if the constraints, conditions and assumptions are violated by the change. The railway sector must not underestimate the effort on maintenance of the related specifications if modularity is increased to a certain extend. Also, the number of different tools required to manage the subsystems and related changes must not be underestimated.

5.3.1.11 The prevention of asynchronous evolution would especially be a task for the system authority (e.g. ERA in case of ERTMS), because with more on-board subsystems the system management activities will grow.

5.3.1.12 Modularity and exchangeable subsystems should also not be considered as a prerequisite for upgradeability. The system design must allow logical components to be upgraded, even if they are not realised as modular, exchangeable subsystems, e.g. a balise transmission module can of course be upgraded individually, even if it is an integral part of the safety platform of the on-board ETCS product from a single supplier.

5.3.1.13 Therefore, a sense of proportion shall be applied when the sector breaks the system into pieces. The introduction of modularity shall be well balanced as desirable qualities such as exchangeability tend to conflict with increased complexity at the system integration level and the maintenance of the overall system consistency over time (e.g. the CCM process, in which functional enhancements can be defined, might have an impact on the system design), see also the detailed analysis in [SP Granularity Principles].

5.3.1.14 Based on the statements above, UNISIG proposes a strategy on the evolution of the existing system design towards a target system compliant with the railway sector's goal.

5.3.1.15 The system design for the future on-board CCS architecture shall be based on the existing functional modules. Break-down of the system into individual logical components or subsystems shall be performed with care to avoid design trade-offs between safety, reliability, and responsibility at the specific application level, where the broken-down system needs to be integrated.

5.4 Commitment towards ECN (Ethernet CCS Consist Network)

5.4.1.1 UNISIG has made a commitment to start the evolution to a standard network based on ECN as per [IEC61375-3-4] for the interfaces among the subsystems for the full OSI layer stack (OSI layers 1 to 7) on the mid-term. This commitment will lead to the so-called *Ethernet CCS Consist Network*, which means the specification of one single technical solution for the communication layer of the on-board CCS subsystem.

5.4.1.2 The requirements for such a standard network shall be fully specified and the technology needs to be available in the foreseeable future. In particular, OSI layers 5 and 6 have not been harmonized yet and there exist multiple variants that are compatible with [IEC61375-3-4] without being compatible with each other.

5.4.1.3 Decisions shall be taken whether the standard network will also be used both by the vehicle networks (e.g. for non-CCS applications) and the on-board CCS or whether the on-board CCS will use a specific network technology also based on [IEC61375-3-4] but not necessarily compatible with other networks on a vehicle.

5.4.1.4 The first step for the definition of the Ethernet CCS Consist Network was done with the [CCS TSI]. The railway sector defined the first two layers (communication layers) plus conditions for other layers with the specification [Subset-147]. This will make it possible to prepare newly developed vehicle designs for the Ethernet CCS Consist Network, although it has not been fully specified. As a side-effect, this limits the number of Ethernet derivates for upper layers to a small number.

5.4.1.5 The technical solution of the Ethernet CCS Consist Network is prepared by the ERJU Innovation Pillar. It is planned to be published with a future CCS TSI, most probably in 2029.

5.5 Scalability

5.5.1.1 The definition of the standard network of the future system architecture shall also consider requirements on scalability to be future proof for functional enhancements and a better separation of safety-related from non-safety related subsystems.

5.5.1.2 Scalability shall in the future be addressed by defining an ETCS on-board API, which means that future subsystems connected to the ETCS on-board can communicate based on the same bus technology with the application SW of the ETCS on-board. As soon as the SW of the ETCS on-board provides the API for a specific enhancement, the related subsystem providing the enhanced functionality can be integrated to the on-board CCS subsystem.

5.6 Migration strategy

5.6.1.1 Supplier internal analysis revealed that major costs during system integration are resulting from changes or lack of harmonization of the application layer (layer 7 according to the OSI model) due to obligatory changes in complex parts of the SW and complex safety argumentations. Usually, this triggers new assessment, certification, and authorisation. 75% of the savings due to network harmonization will be achieved through harmonization of the application layer. Furthermore, this abstraction will reduce any migration cost to new networks.

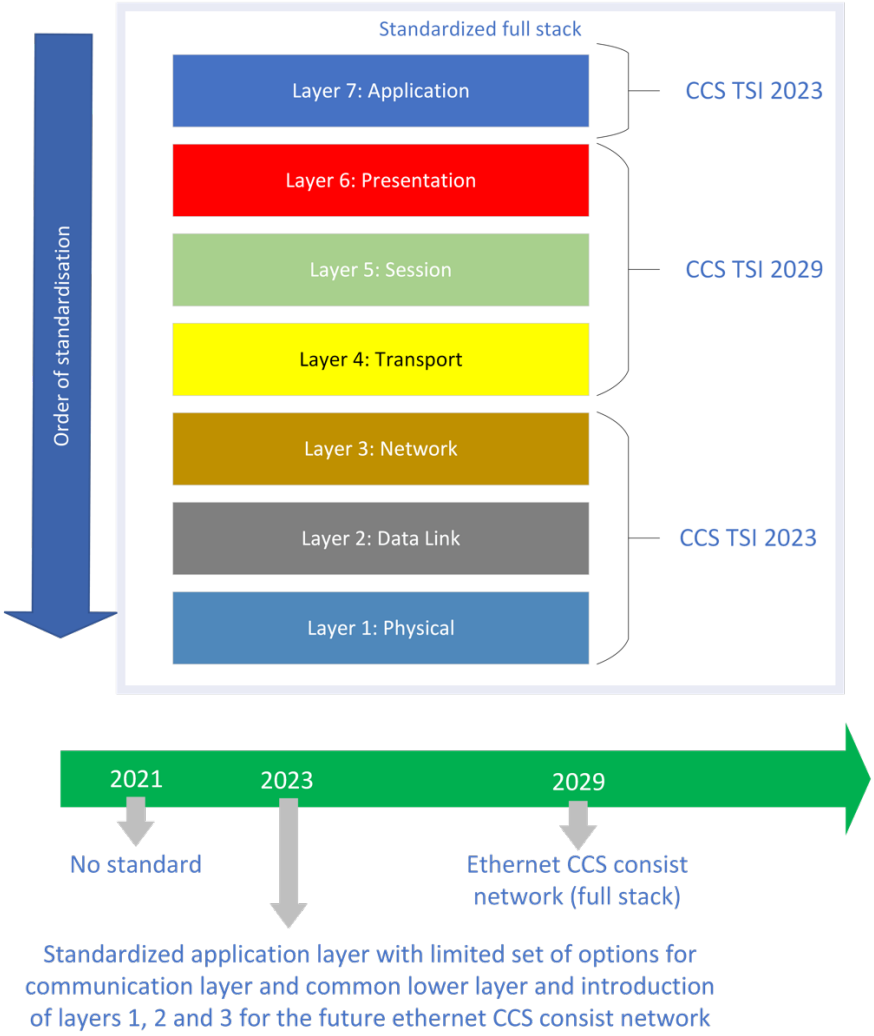

Figure 2 – Order of standardisation

5.6.1.2 For lower layers (below layer 7) the procedures for safety justification and authorisation are simpler, even though it is needed to repeat integration tests.

5.6.1.3 In case of the Ethernet CCS Consist Network a benefit of harmonizing layer 1 to layer 4 is the reuse of cabling (Ethernet - Cat 6 or Cat 7) but there is no clear benefit on end devices (e.g. a subsystem of the on-board CCS architecture) themselves. In addition, harmonizing the lower layers 1 to 3 could lead to a common foundation for the rolling stock network and the on-board CCS subsystem (incl. cyber security). This would facilitate technological decision for the upper layers and applications.

5.6.1.4 Existing investments must be protected by keeping the main subsystems of the ERTMS reference architecture stable. This will make sure that the installed base can be more easily upgraded to new technology, if necessary.

5.6.1.5 Therefore, a migration strategy shall be followed, which should focus on the preparation of the specifications of the system towards the future goal on the short-term and the realization of the goal on the long-term. The short-term must aim to quickly achieve the benefits as stated in 5.3.1.1. The achievement of the long-term goal must be planned under consideration of a reasonable transitional period, e.g. through the Annex B of the [CCS TSI].

5.6.1.6 The migration strategy for the Ethernet CCS Consist Network involves the following steps which will be specified in greater depth in Section 6:

- Priority 1: harmonization of the layer 7 (application layer) to quickly achieve the savings as described in Section 5.6.1.1;
- Priority 2: harmonization of the lower layers 1-3 to achieve a technology specifying a common foundation for the on-board network technology as stated in Section 5.6.1.3;
- Priority 3: harmonization of the remaining layers.

5.6.1.7 The migration strategy shall be supported by a level of freedom for suppliers' design decisions, e.g. inclusion of logical components into supplier specific subsystems or by keeping the possibility of grouping interoperability constituents, where interfaces internal to the group of interoperability constituents can be designed in a proprietary manner. This will in addition support the possibility of innovations (e.g. the design of more compact, more efficient or cheaper products upon request of the purchaser) without jeopardizing interoperability. This should be a general principle and foreseen not only during the migration phase.

5.6.1.8 Intermediate steps within the migration process towards the target system should be foreseen to allow the introduction of new requirements (such as cyber security) or the introduction of functional enhancements (such as Game Changers) on the mid-term. The whole concept should anticipate these steps to limit the impact on the short-term architecture. This also implies that until the sector achieves a certain level of standardization, a limited number of existing options shall be accepted.

5.6.1.9 The train interface between the on-board CCS and the rolling stock (or the so called TCMS) subsystem is one example where these guiding principles have already been followed, evolution of which has been pioneer to other changes of the on-board CCS subsystem. This interface has evolved from being defined at a functional level only (FIS ([Subset-034])) to the solution level (FFFIS ([Subset-119]) and [Subset-147]), which is now mandatory according to the [CCS TSI] at least for newly developed vehicle designs requiring a first authorisation.

5.7 Suggestions on the legal framework

5.7.1.1 The current sector's goal on the evolution of the on-board CCS subsystem according to Section 5.1.1.1 is not only focussed on interoperability, but also on protection of investment and an adaptable approach for system upgrades. This could be reached by better manageable integration or an increased level of exchangeability.

5.7.1.2 According to the EU railway directive [(EU) 2016/797] interoperability *means the ability of a rail system to allow the safe and uninterrupted movement of trains which accomplish the required levels of performance*.

5.7.1.3 Hence, interoperability does not encompass exchangeability or the manageability of integration. So, these characteristics are not part of the EU directive's objectives, even if the alleged absence of these characteristics is considered a market failure. These are additional characteristics of a system or a subsystem of a system that the railway sector can achieve by establishing a corresponding standard.

5.7.1.4 Based on these standards, purchasers can order an exchangeable subsystem, but requirements on exchangeability shall be left outside the TSIs and the related authorisation processes if the system complies to the interoperability (incl. safety) requirements.

5.7.1.5 Therefore, like other industrial sectors, manageability of integration or exchangeability should be governed through standardisation activities and enforced by contractual stipulations. Combining authorisation with the correction of market failures will increase authorisation cost and jeopardize the deployment of safely working vehicles, that fully meet safety and interoperability requirements from the operational point of view.

5.7.1.6 Furthermore, the current legal framework is not prepared to distinguish different authorisation processes for different higher-order characteristics, such as safety-related or non-safety-related. Each basic parameter in the [CCS TSI] is seen as a requirement to be checked during conformity assessment (interoperability constituent level), EC verification (on-board CCS or rolling stock subsystem level) and authorisation (vehicle level).

5.7.1.7 Future authorisation and the related independent assessment by assessment bodies (such as notified bodies or safety assessment bodies) should be limited to functional safety, safe integration and major interoperability requirements and not involve exchangeability or non-safety-related elements on the subsystem and vehicle level. Furthermore, corrective changes for safety-related functions or subsystems must be simplified from the authorisation perspective. This shall also consider leaving changes to improve protection against security threats out of authorisation activities.

5.7.1.8 Especially for CCS, the railway sector suffered from immature specification which were referenced as legally binding in the TSI. This led to regular error correction CRs, national

technical rules and huge challenges for the suppliers to provide systems, which are compliant to the standard and safe at the same time.

5.7.1.9 This comes along with different understanding among sector stakeholders of widely used terms like partial fulfilment or deviations, which are often used to implement stricter regimes in the [CCS TSI] on assessment or testing (e.g. ESC), although the root cause of partial fulfilment or deviations are manifold (e.g. immature or unclear specifications). It is crucial to exercise caution when using these terms to make informed decisions about improving the certification, and authorisation processes.

5.7.1.10 UNISIG proposes to agree on an adequate technology readiness level for new specifications before they become legally binding. Technology readiness level could be reached through prototypes and qualification phases for a specified period agreed on a pan-European basis. This applies not only to functional enhancements but also to error corrections. The latter is particularly crucial for expediting the progress towards enhancing performance, availability, and reliability.

6. ANALYSIS AND STRATEGY FOR THE FUTURE ARCHITECTURE

6.1.1.1 Based on the guiding principles according to Section 5, UNISIG has defined a strategy for the evolution of the existing system architecture to the target.

6.1.1.2 UNISIG proposes to introduce based on the existing architecture more modularity for future development combined with updates of specifications to pave the way to the target on-board CCS architecture.

6.1.1.3 The strategy involves a four stages approach as described in the following sections.

6.1.1.4 The architectural drawings are shown in Section 10.

6.2 Activities performed for the CCS TSI 2023

6.2.1 Introduction

6.2.1.1 This section describes the activities already carried out prior to the publication of the [CCS TSI] in 2023.

6.2.2 Preparation of the Ethernet CCS Consist Network

6.2.2.1 It was decided to retain existing interfaces and the ability to use legacy networks. However, certain interface specifications for the CCS On-board architecture were refined, as per the commitment made in Section 5. These are:

- [Subset-119] for the interface of the ETCS on-board to the train,
- [Subset-130] for the interface between the ATO on-board and the ETCS on-board,
- [Subset-139] for the interface of the ATO on-board to the train and
- [Subset-140] for the interface between ATO on-board and the juridical recording.

6.2.2.2 In its previous versions (prior to its publication through the [CCS TSI]), [Subset-119] included the full stack of the interfaces with several options, which included legacy networks (e.g. MVB and CAN).

6.2.2.3 For the [CCS TSI] in 2023 and for newly developed vehicle design this specification was changed by removing the communication layer requirements (OSI layer 1 to 6) to make it a pure application layer specification, independent from the communication layer and to be prepared for the Ethernet CCS Consist Network (see Section 5.4.1.2). For existing

vehicles, the communication layer requirements remain as a voluntary guideline for ETCS retrofit projects.

6.2.2.4 [Subset-130], [Subset-139] and [Subset-140] have already been prepared according to this concept from the beginning.

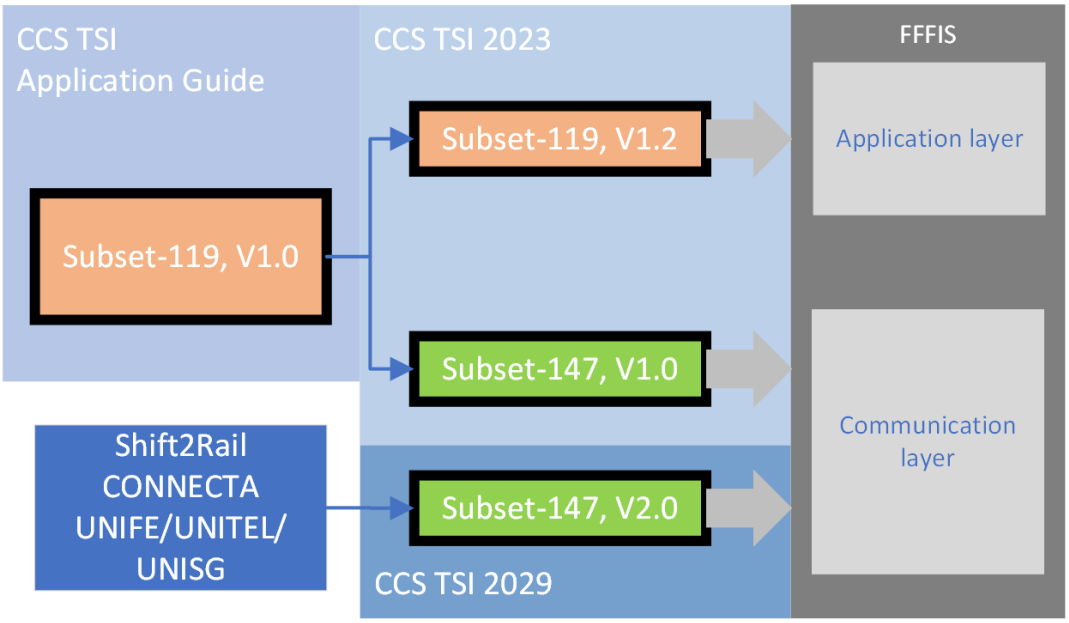

Figure 3 - Separation of application from communication layer

6.2.2.5 For the preparation of the [CCS TSI] 2023 UNIFE and UNISIG prepared for the communication layer the specification [Subset-147] in relation to [Subset-119] , [Subset-139] and [Subset-140].

6.2.2.6 In addition, a fourth specification [Subset-143] has been prepared by the S2R ATO WP primarily for the communication layer of the interface according to [Subset-130]. [Subset-143] is optionally applicable also for the interface according to [Subset-139]. Therefore, also [Subset-147] refers to it.

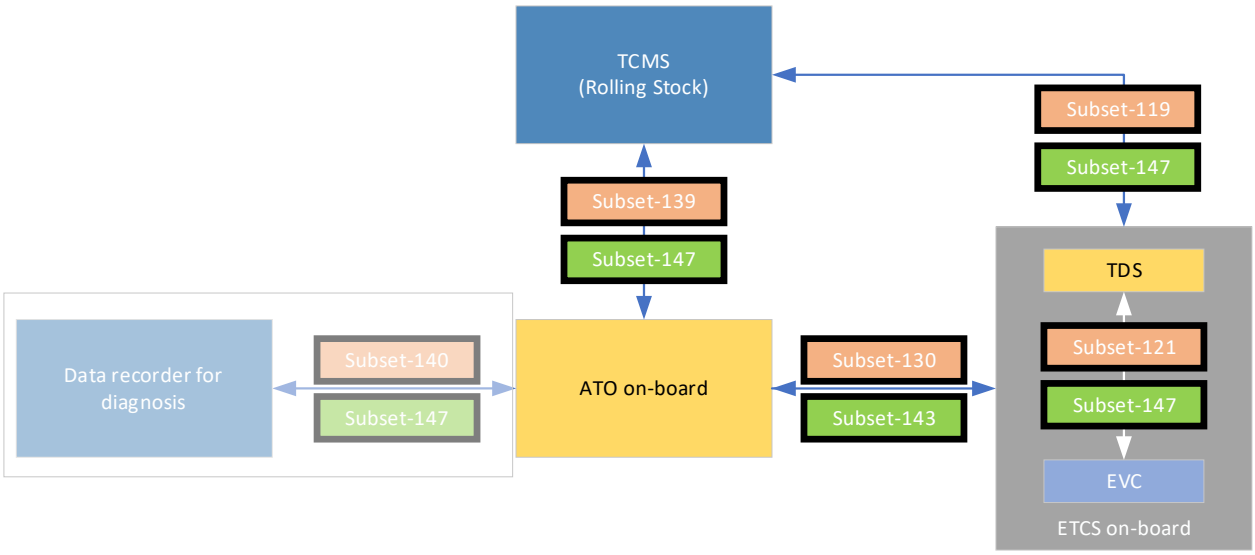

Figure 4 - Interfaces and related specifications for ETCS & ATO on-board and TCMS

6.2.2.7 This strategy abstracted the application layer from the communication layer, leading to more stable specifications and implementations of the application layer. It also fixed a set of optional legacy technologies for the transition period, allowing the system integrator (normally the vehicle manufacturer) to choose at its discretion. This removed the risk of introducing new technology which will become obsolete soon after implementation of the target on-board CCS architecture (including the Ethernet CCS Consist Network).

6.2.2.8 Based on this strategy and with respect to Section 5.6.1.1 future functional enhancements (like game changers) could be introduced more cost efficiently under the condition that their introduction does not trigger a new authorisation.

6.2.3 Preparation for FRMCS readiness

6.2.3.1 It was clear that the planning and the specification of FRMCS was not ready for the [CCS TSI] in 2023.

6.2.3.2 Anyway, the impact on a later introduction of FRMCS on all other subsystems of the on-board CCS subsystem and the rolling stock subsystem shall be limited to the absolute minimum (e.g. the need for changes on safety-related elements due to the introduction of FRMCS). Therefore, UNISIG with EUG and ERA introduced for [CCS TSI] 2023 the concept of “FRMCS readiness”.

6.2.3.3 “FRMCS readiness” means that all safety-related elements of the on-board CCS architecture, changes of which would trigger a new authorisation, should be fully

prepared for FRMCS. A later installation of FRMCS subsystems should not have any effect on them.

6.2.3.4 This means that analysis to achieve “FRMCS readiness” shall primarily focus on the requirements for the EVC (as part of the interoperability constituent ETCS on-board) as it is the SIL4 element of the on-board CCS architecture. This concerns mainly the safe part of the Euroradio protocol according to [Subset-037], but also [Subset-026].

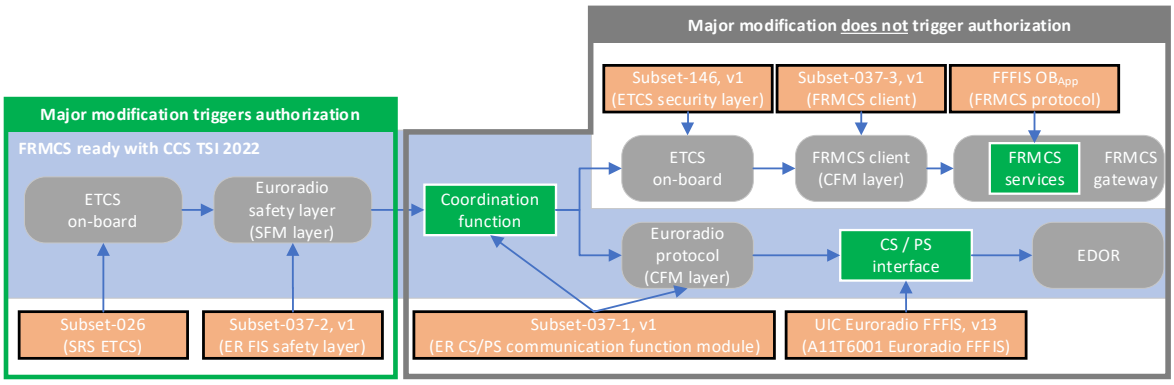

Figure 5 - FRMCS readiness concept

6.2.3.5 To prepare the Euroradio protocol, UNISIG split the [Subset-037] into three parts.

- Subset-37-1 for the safety layer,
- Subset-37-2 for the coordination function (coordination to route data to the legacy EDOR or to the new FRMCS on-board gateway) and
- Subset-37-3 for the FRMCS client within the ETCS on-board (outside the EVC).

For the [CCS TSI] 2023 and to prepare the ETCS on-board for FRMCS the preparation of [Subset-037] part 1 and 2 were sufficient. Part 3 will be introduced to the CCS TSI at a later stage.

6.2.3.6 For the FRMCS readiness concept to be successful, the regulatory framework will also need to be amended accordingly, which has not yet been achieved with the [CCS TSI] in 2023. The definition of the interoperability constituents in the next CCS TSI should more clearly distinguish between safety-related and non-safety-related. This would allow a more efficient approach for non-safety related subsystems of the on-board CCS architecture.

6.2.3.7 In particular, for the vehicle authorisation process the basic design characteristics could then better distinguish which type of change results in a vehicle type variant (trigger a new authorisation) or a vehicle type version (typically not triggering a new authorisation).

An example is given below. More detailed proposals for changes to the regulatory framework are included in Section 9.

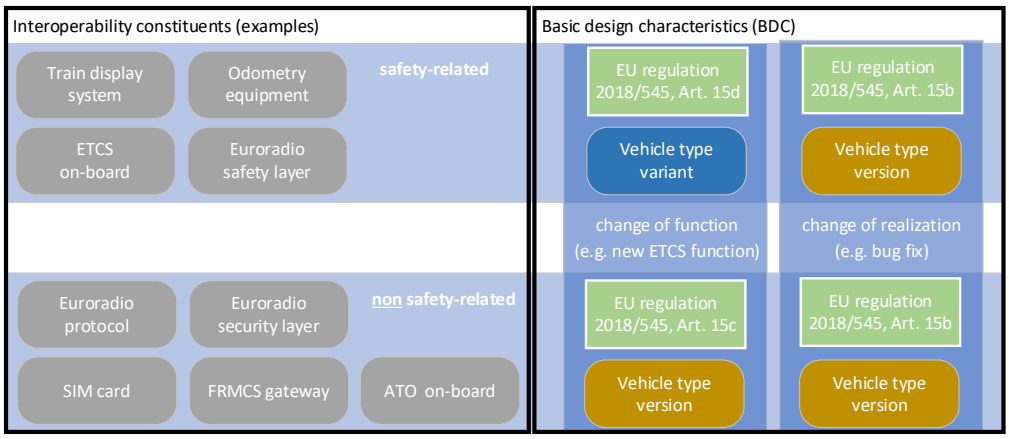

Figure 6 - Separation of safety-related from non-safety-related and impact on authorisation

6.2.3.8 The same principles are being used to coordinate GSM-R and FRMCS communication for ATO. This is described in [Subset-148].

6.3 Stage 1: Short-term (next major CCS TSI update (approx. 2028/2029))

6.3.1 Introduction

6.3.1.1 The short-term proposal will be the definition of the on-board CCS subsystem for the next major CCS TSI update. It is based on the existing design and will introduce the FRMCS, DAC and cyber security. But it will involve further enhancements of existing specifications (e.g. for the Train interface, Subset-119) for the on-board CCS architecture.

6.3.2 Evolution of the Ethernet CCS Consist Network

6.3.2.1 The existing interfaces and the possibility to use legacy networks remain. However, certain interface specifications will be further refined for the future short term CCS On-board architecture, as per the commitment made in Section 5.4. These will be [Subset-119], [Subset-130], [Subset-139] and [Subset-140].

6.3.3 Preparation of Game Changers

6.3.3.1 Introduction

6.3.3.2 FRMCS, ETCS Hybrid Train Detection, ETCS Moving Block and ATO up to GoA4 are future game changers of the on-board CCS subsystem, which will have a direct impact on the on-board CCS architecture.

6.3.4 Migration of Baseline 3 On-boards to FRMCS with *SV 2.1 plus CR1359*

6.3.4.1 In the first half of 2024 a joined working group (CTO council) comprised of railways and the supply industry prepared a concept for the lean upgrade of Baseline 3 compliant ETCS on-board to FRMCS readiness, called ETCS baseline light.

6.3.4.2 The essence of the approach was that only the non-safety-related parts of Euroradio needed to be changed, which would lead to the benefits described in Section 6.2.3.

6.3.4.3 This concept was refused by parts of the sector stakeholders and ERA, because of its operational trade-offs as not fully compliant to ETCS Baseline 4.

6.3.4.4 The railways and UNISIG continued to work on an alternative, that would implement a fully Baseline 4 compliant FRMCS readiness solution (as per CR1359), that would not have the operational trade-offs. This concept is called “SV 2.1 plus CR1359”.

6.3.4.5 Key elements of the “SV 2.1 plus CR 1359” approach are:

- use and keep the existing CR1359 solution;
- omit all other BL4 enhancement CRs;
- implement error CRs included in Baseline 4 only if interoperability issues have to be resolved;
- differentiate safety relevant and non-safety relevant requirements in the next CCS TSI which shall lead to a relaxation of the authorisation process, see Sections 6.2.3 and 9.

6.3.4.6 Further details and the need for changes to CR1359 to be compatible with SV 2.1 still require analysis by the UNISIG Supergroup.

6.3.4.7 A Comparative Economic Impact Assessment (CEIA) shall demonstrate the same level of cost savings as the one we performed for Baseline Light; this CEIA should be conducted with ERA involvement.

6.3.5 Cyber Security

6.3.5.1 Cyber security has already become one of the major higher-order characteristics of systems or subsystems. The goal is to achieve security-by-design of the on-board CCS subsystem, which means that the subsystems have been designed from the ground up to be secure against cyber-attacks.

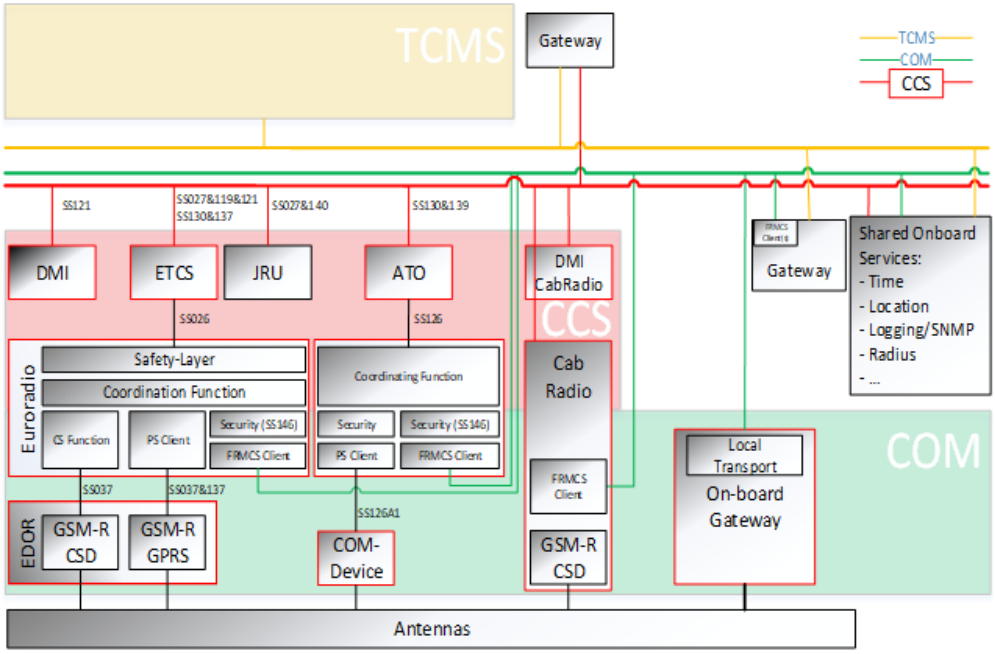

Figure 7 - Security Zones for TSI CCS 2028/29

6.3.5.2 The ERJU system pillar has published a technical security specification which (in parts) can be applied for the future on-board CCS architecture. The security specifications applied for the on-board CCS architecture will be restricted to security requirements required for interoperability (e.g. interfaces to limited set of shared cybersecurity services).

6.3.5.3 Separation of security zone / network segments: ECN gateway and other proposed gateways are on layer 3 for defined transitions between cyber security zones. Euroradio is seen as a gateway between two networks. It is connected to two network segments: CCS and COM (see Figure 7). If such a construction only handles Layer 3 information it is called a router, if it handles also higher layers, it is called a gateway. From this point of view, Euroradio is a gateway, because it handles layer 4 in the media plane.

6.3.5.4 A dedicated cyber security zone may be required for shared services, or it may not be necessary.

6.3.5.5 Figure 7 shows the security zones for CCS TSI 2029. The CCS network has to support multiple zones, isolated by default with dedicated Quality of Service requirements (e.g. latency, availability, isochronal). Zones can be physically isolated or implemented as VLAN.

6.4 Stage 2: Mid-term (after CCS TSI 2028/2029 release (approx. 2030))

6.4.1 Introduction

6.4.1.1 The mid-term proposal will be the definition of the on-board CCS subsystem for the CCS TSI following the CCS TSI 2028/2029. It is again based on the existing design, but will close open points, which could not be solved for the CCS TSI 2028/2029 and will introduce FRMCS as the radio baseline 2.

6.4.1.2 There is also a desire within the sector for Basic Advanced Safe Train Positioning (Basic ASTP (enhancing the specified performance based on existing technology, creating an interface specification for the input and output for Full ASTP for later extension)) to be introduced via the CCS TSI at around the same time. This chapter therefore also sets out UNISIG's current position on Basic ASTP.

6.4.2 FRMCS introduction

6.4.2.1 It is assumed that with the mid-term architecture the specifications for FRMCS technology are available.

6.4.2.2 The CCS TSI will introduce the FRMCS specification by defining a new radio baseline 2.

6.4.2.3 The connection of the FRMCS on-board gateway to the ETCS on-board will be realised through the Euroradio protocol as defined in [Subset-037]. On the ETCS on-board side this will be realised by the FRMCS client, which will be specified by part 3 of [Subset-037].

6.4.2.4 For a transitional period, the ETCS on-board and Euroradio need to handle both the legacy EDOR and the FRMCS on-board gateway. This will be realised by the specific coordination function as specified in part 2 of [Subset-037], see Section 6.2.3 for more details.

6.4.3 Cyber Security

6.4.3.1 It is assumed that along with the introduction of the FRMCS specifications further requirements to achieve security-by-design will be referenced in the CCS TSI.

6.4.3.2 This section will further specify in a subset of the ERJU System Pillar cyber security concepts (based on the security specification as referred to in Section 6.3.5.2), e.g. interfaces to extended set of shared security services.-

6.4.4 Basic Advanced Safe Train Positioning (Basic ASTP)

6.4.4.1 There is a desire to define the basic ASTP system as an independent subsystem or interoperability constituent. UNISG has the following position on this**:**

6.4.4.1.1 UNISIG holds the opinion that it is not useful to standardise a separate exchangeable subsystem as interoperability constituent before Full ASTP is introduced from economical and technical strategic point of view.

6.4.4.1.2 Basic ASTP shall provide improved odometry performance, with a strong focus on improved “availability” or “continuity” (not exceeding performance requirements due to “normal” environmental conditions, such as slip/slide or weather), and also some improved accuracy, compared to the currently specified minimum values in [Subset-041].

6.4.4.1.3 Basic ASTP shall not use any additional supporting information to be provided by the onboard CCS, such as a track map, EGNOS, route data etc. (see the architecture descriptions in [IP ASTP Design] of R2DATO of the ERJU Innovation Pillar as assumptions on the future architecture of Full ASTP).

6.4.4.1.4 Basic ASTP shall also not generate additional outputs, beyond what ETCS requires today.

6.4.4.1.5 This first (Basic) ASTP step shall not have any constraint on trackside.

6.4.4.1.6 Consequently, there are no activities towards standardisation in relation to basic ASTP. The improvement of current solutions to reliably and robustly comply to the current standards is a matter of improvement of industrial solutions and does not affect standardisation. This might change in the future if new technical solutions are available and sufficiently proven to be ready for use in commercial operation. New technical solutions which require enhancements of existing interfaces between the systems or which will even introduce new interfaces or systems will enforce provision of adequate standardisation.

6.4.4.1.7 Any reduction in the number of balises shall be due to improved performance only and not to the use of any form of 'virtual reference points' (which would probably require a map). We also need to consider compatibility with Baseline 3 ETCS on-board systems, which will probably not allow reducing the number of balises.

6.4.4.2 In the following sub-paragraphs, an analysis of the rationale behind introducing an exchangeable subsystem in 2029 will be presented. From the discussion in the ERJU System Pillar we understand the following rationale:

6.4.4.2.1 Multiple elements within the vehicle need localization information. An exchangeable ASTP subsystem shall enable future odometry enhancements without impacting the other on-board CCS subsystems, especially the ETCS on-board.

6.4.4.2.2 An exchangeable subsystem Basic ASTP, before the introduction of Full ASTP, makes available the new interoperability constituent and its interfaces at the same time with the major FRMCS change to encourage Railway Undertakings to invest.

6.4.4.2.3 If the clear segregation between the ERTMS/ETCS on-board and the odometry system is not available for the CSS TSI 2028 or 2029, Railway Undertakings might not be able to handle two major updates (FRMCS + ASTP) in just a few years.

6.4.4.2.4 In order to avoid two major CCS on-board modifications in just a few years: FRMCS in 2028 and Full ASTP in 2032, it is requested to aim for a first ASTP migration step by 2028/2029 by making the odometry function independent of the ETCS on-board subsystem, i.e. by delivering an (Basic) ASTP FRS and an ETCS on-board / ASTP FFFIS.

6.4.4.3 UNISIG analyses the rational and positions itself as follows:

Maturity of Full ASTP solution

6.4.4.3.1 To be able to provide an interface specification compliant with the Full ASTP solution already by 2029, an initial effort on the Full ASTP solution concept would be necessary to consolidate the new future needs from existing consumers and the needs of new future consumers, in order to be able to provide a stable functional allocation and interface specification. But this does not seem to be possible for 2029.

6.4.4.3.2 The specification for Full ASTP can be started once an initial set of agreed requirements has been defined and once the full impact on [Subset-026] (in terms of current odometry requirements deletion), and impact on the supply industry (time to market, cost etc.) is clear.

Investments needed for Full ASTP

6.4.4.3.3 Introducing Full ASTP will require significant changes to the on-board CCS subsystem, e.g., to introduce the on-board digital register (digital track map) and the other supporting information. Introducing Full ASTP, with the supporting information, will not only be done to save a few balises, but will require additional functionality to justify its costs. This could e.g., be remote driving, or ATO GoA 3/4, which might require perception, which in turn might need Full ASTP to provide the additional outputs, e.g., altitude. Such new functionality will however be very likely to also impact the ETCS on-board heavily.

6.4.4.3.4 The ETCS on-board will therefore have to be updated anyway, when Full ASTP is introduced.

As defined for Basic ASTP, it shall not use any additional supporting information to be provided by the on-board and trackside CCS, such as a track map, EGNOS, dynamic point data, dynamic route data etc. In addition, for Full ASTP at least a GNSS receiver, a digital track map and an extension of the Basic ASTP interface are currently considered to be needed, so for Full ASTP the operators have to invest again in 2032 so that two major CCS on-board modifications in just a few years cannot be avoided (2029 for FRMCS and 2032 for Full ASTP).

Analysis and correction of product errors

6.4.4.3.5 A major argument for keeping the odometry integrated in the ETCS on-board is that it is a core function of ETCS and typically a very complex element of the ETCS on-board, developed by the same supplier. In case of project specific problems with the odometry, experiences show that a deep analysis of the odometry implementation in interaction with the implementation of ETCS functions is necessary. Such a deep analysis would be much more difficult and would need more efforts if the ETCS on-board and the odometry are implemented by different suppliers. This is seen as a real problem for product error correction. It might be project-specific and very problematic to determine who is responsible for an error and its correction. This clarification might lead to high delays in the maintenance process.

6.4.4.3.6 This is supported by the fact that the ETCS on-board is the only consumer of a SIL 4 odometry. Therefore, it would not add any value to separate a SIL 4 odometry from the the safe supervision by the ETCS on-board.

Real objective for CCS TSI 2029: improve the accuracy and the performance of the odometry

6.4.4.3.7 UNISIG understands that the operators have an interest to improve the accuracy and the performance of the odometry. For this core problem the separation of the odometry would not have a direct influence. There is even the risk that the change for existing ETCS on-boards and supplier specific solutions for the odometry and supplier specific solutions for the interaction between ETCS on-board core functionality and the odometry might have a negative impact on the odometry performance and accuracy. Instead, the focus should be on the improvement of the interaction of the ETCS on-boards with the vehicles. Specific requirements for the different types of vehicles (yellow fleet, locomotives and train sets) seem to be more important to improve the odometry performance in the application specific context.

6.4.4.3.8 On some types of vehicles, achieving today‘s targets from [Subset-041] is very difficult and on some vehicles significantly better performance can be achieved. The [Subset-

041] specifies the minimum odometry performance required. Even today, therefore, we can have better performance values without the need to have a separate odometry.

Protection of investments

6.4.4.3.9 In general, existing investments shall be protected by keeping the main elements of the ERTMS reference architecture stable. This applies also for the odometry with the current technology, which is in the architecture of [Subset-026] part of the ETCS on-board. This will make sure that the installed base can be more easily upgraded to new technology, if necessary.

6.4.4.3.10 Also, the impact to potentially separate the balise reader from the ETCS on-board for Full ASTP must not be underestimated.

Unnecessary efforts on the way towards the Full ASTP

6.4.4.3.11 The elimination of the Basic ASTP could lead to an acceleration of the standardization of the Full ASTP, concentrating efforts on the Full ASTP. It shall be kept in mind the we are not starting from scratch: there is all the specification work done in S2R projects (e.g. X2R2, WP3 “Fail-Safe Train Positioning (including satellite technology)”, X2R5, WP05 “Fail-Safe Train Positioning Specification”, WP06 “VB Fail-Safe Train Positioning” Development and Testing”, and WP07 - “Stand-Alone Fail-Safe Train Positioning” Development and Testing).

6.4.4.4 UNISIG considers the following as being alternatives for exchangeable subsystem ASTP:

6.4.4.4.1 One idea behind an exchangeable subsystem ASTP is to provide position information to other onboard systems.

6.4.4.4.2 The separation is not a precondition, because another option exists to achieve the same result: existing odometry system integrated into the ETCS on-board can provide the position information to other onboard systems.

6.4.4.4.3 A harmonised FFFIS is not needed for ETCS on-board but for test purposes and maybe other applications that need odometry data.

6.4.4.4.4 Formally, the odometry is already an interoperability constituent in the [CCS TSI] (ID 2 in Table 5.1, Odometry equipment) (although the relevant interface and test specifications are missing). A change should be limited to have a harmonised FFFIS for test purposes and other applications that need odometry data (including a test specification, which needs to cover all sensor technologies which might be used by a specific implementation of odometry).

6.4.4.4.5 This might lead to better solutions, because some suppliers might be able to develop beneficial solutions (innovation due to more competition).

6.4.4.4.6 ETCS already has to provide odometry to other users, such as e.g., STMs (see Subset-035 chapter 12 in both BL3 and BL4) and also for ATO (see Subset-130 §6.2.2.2), and ETCS sometimes alters the odometry data for external users. If such alterations are done also in ASTP, then ASTP might have to be updated if ETCS odometry exports changes.

6.4.4.5 In conclusion, UNISIG provides the following summary of its stance on Basic ASTP:

6.4.4.5.1 For 2029 the suppliers clearly see more risks than benefits to extract odometry into an interoperable or exchangeable constituent in their system design. The UNISIG preferred solution is to keep odometry integrated in the ETCS On-board.

6.4.4.5.2 It is agreed that we need a transparent additional interface for the odometry for test purposes but not a separation from the ETCS on-board for Basic ASTP in 2029.

6.4.4.5.3 This can be achieved with a FFFIS for the odometry output and related test specification which has:

- a limited impact on the current CCS TSI, and
- a limited impact for the existing on-boards.

6.4.4.5.4 For Full ASTP there are more relevant arguments for having a separate interoperable constituent including FFFIS interfaces for inputs (as GNSS receiver or a digital track maps) and outputs to ETCS, ATO and other consumers for interoperability reasons and limit the technologies which can be used.

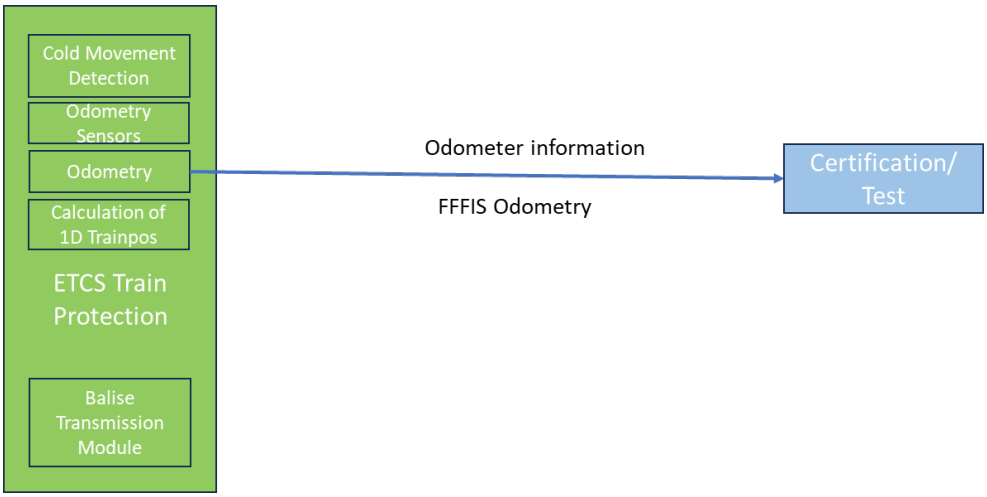

Figure 8: UNISIG's position for BASIC ASTP architecture

6.5 Stage 3: Long-term (after CCS TSI 2030 release (approx. 2032))

6.5.1 Introduction

6.5.1.1 The long-term proposal will be the definition on the on-board CCS subsystem for a future [CCS TSI], probably in force in 2032 or later. It will be the target system as it fully standardizes all interfaces between CCS and Rolling Stock among the exchangeable elements (excluding legacy NTCs) based on the Ethernet CCS Consist Network.

6.5.1.2 There is also the desire for Full Advanced Safe Train Positioning (Full ASTP (delivering reliable distance to the LRBG as an independent logical function which lies in small confidence interval)) to be introduced via the CCS TSI at around 2032. This chapter therefore also sets out UNISIG's current position on Full ASTP.

6.5.2 Multi-Display System (MDS)

6.5.2.1 The MDS on-board is understood as a service providing a displaying function of multiple applications including among others ATP, ATO and TCMS.

6.5.2.2 As of 2025, the MDS is a concept, for which technical aspects and benefits are unclear.

6.5.2.3 The introduction of MDS needs an economic justification and clear benefits for both users and suppliers.

6.5.2.4 Should TCMS be supported by the MDS, then a close collaboration between the CCS suppliers and the vehicle manufacturers is necessary, to ensure that the MDS is designed according to both CCS and TCMS needs and constraints.

6.5.2.5 The compatibility of MDS with legacy NTCs and their specific implementation is considered as out of scope.

6.5.2.6 The economic justification, along with technical feasibility of MDS, can be studied in the context of the ERJU Innovation Pillar.

6.5.3 Full Advanced Safe Train Positioning (Full ASTP)

6.5.3.1 Advanced Safe Train Positioning (ASTP) allows an improved safe localization of the train using also additional and advanced technologies as satellite positioning.

6.5.3.2 For Full ASTP there are more relevant arguments in comparison with Basic ASTP for having a separate exchangeable subsystem including FFFIS interfaces for inputs and outputs to ETCS, ATO and other consumers for exchangeability reasons and to limit the technologies which can be used.

6.5.3.3 It is expected that introduction of ASTP will require new technology that involves different subsystems of CCS or leads to the introduction of new subsystems in the context of CCS. To maintain interoperability, amendments to the affected interface are required.

6.5.3.4 If it finally makes sense to standardise a separate exchangeable subsystem as interoperability constituent, then it must be analysed carefully from economical and technical strategic point of view.

6.5.3.5 Issues related to the integration and test to be provided for an interoperable constituent Full ASTP must be considered. The introduction of a new interoperable constituent shall require the definition of a comprehensive test specification. A common and comprehensive test specification is a challenge because the ASTP function uses INS-type technologies, and having a common simulation model seems very complex. If it is too simplistic, we fall back on the issues and weaknesses of the current [Subset-041] tests.

6.5.3.6 Whether supporting information transmitted from the wayside to the onboard shall use independent channels and not impacting the ETCS communication ([Subset-026]) needs to be analysed. The specification and harmonization of these interfaces need to be carried out in the context of the Full ASTP specification.

6.5.3.7 In case of a separation of ASTP the front-end position information shall be calculated and provided by the ETCS on-board.

6.5.3.8 If deemed necessary, additional data generated by Full ASTP (e.g., altitude, rotation rates, 3D position) shall be provided by the ETCS on-board to additional interfaces.

6.5.3.9 Most other on-board subsystems require the “train front position” as location information. The ETCS on-board determines this information. The calculation of the train front with respect to the positioning system is a functionality carried out by ETCS, so redundant ASTP functionality would be avoided. It will avoid ASTP inputs for active cab, train length and integrity values in a safe manner.

6.5.3.10 Supporting information transmitted from trackside to onboard, which will be part of the standardized Full ASTP, shall be introduced in one step to avoid multiple variants.

6.5.3.11 GNSS, if specified to be part of the standardized Full ASTP, shall be introduced in one step to avoid multiple variants (e.g. not single constellation / single frequency and then upgraded in steps up to dual frequency / dual constellation).

6.5.3.12 Providing the full set of supporting information transmitted, which will be part of the standardized Full ASTP, shall be mandatory for the trackside where Full ASTP shall be used, the provision shall not be “optional”.

6.5.3.13 Whether the balise reader is part of ASTP or whether it remains part of ETCS needs to be clarified.

6.5.3.14 In this clarification it needs to be taken into account that at moment the balise reader is an integral part of the ETCS on-board. So far, the [CCS TSI] does not contain a specification of the balise reader. In addition, the more subsystems there are, the more complex the interfaces become. The number of interfaces increases with the number of subsystems and so does complexity. With increase of the number of subsystems the integration effort will grow.

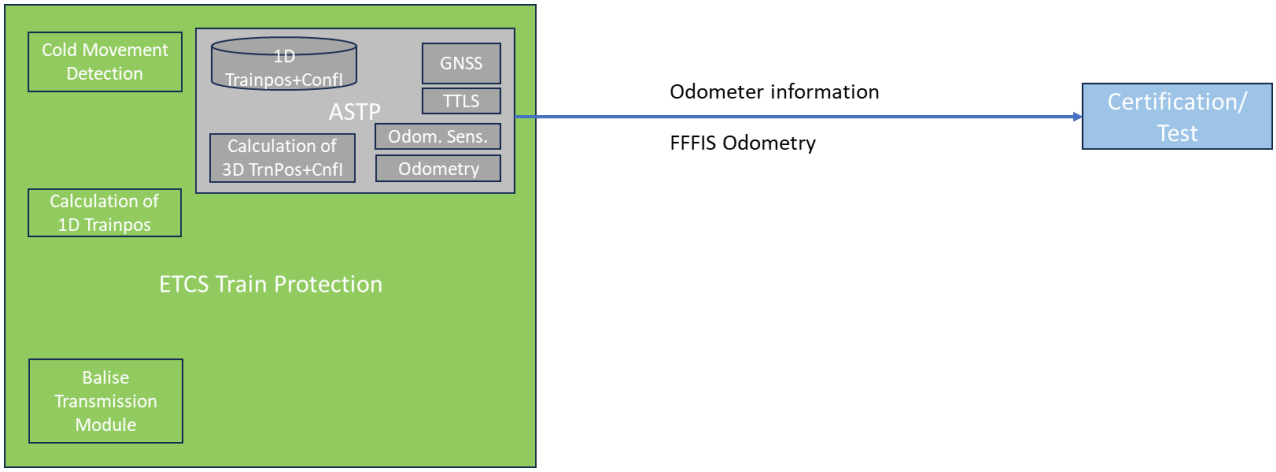

Figure 9: Option 1 for ASTP Architecture

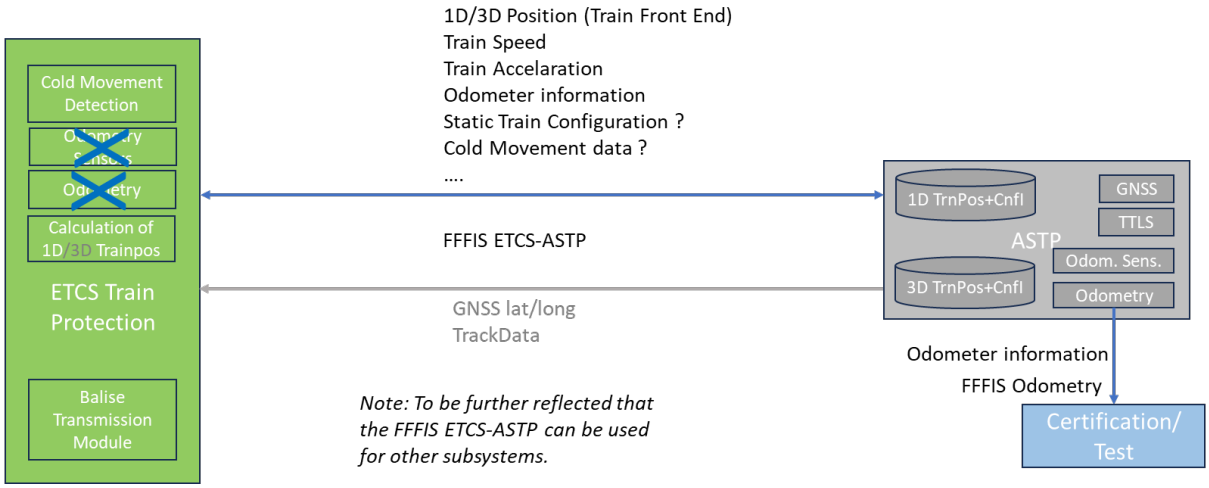

Figure 10: Option 2 for ASTP Architecture

6.5.4 ATO up to GoA4

6.5.4.1 ATO up to GoA4 will be an important game changer, bringing clear benefits in terms of flexibility and optimum capacity use of the mainline railway system.

6.5.4.2 The introduction of ATO up to GoA4 will generate impacts to the CCS On-board, as it is not designed today to be used in an unattended way.

6.5.4.3 These changes must be apprehended in a holistic view, with the overall railway system under consideration, not limited to the CCS, but also considering operations in [OPE TSI]. In addition, ATO up to GoA4 will export functions and constraints to the subsystem Rolling Stock.

6.5.4.4 ERJU Innovation Pillar Flagship Project 2 R2DATO is developing operational concepts for ATO up to GoA4.

6.5.4.5 These developments shall be further continued in ERJU System Pillar Operational Design.

6.5.4.6 ATO up to GoA4 for the CCS On-board is composed of Automatic Driving Module and Automatic Processing Module.

6.5.4.7 Automatic Driving Module is to be understood as the ATO-OB as per [CCS TSI] 2023 [Subset-125]. This component is strictly related to the traction and braking of the rolling stock [Subset-139], with respect to the ERTMS/ETCS signalling [Subset-130] and the timetable [Subset-126].

6.5.4.8 Automatic Processing Module is the extension of Automatic Driving Module, taking in charge new roles and responsibilities within the on-board perimeter, to enable GoA3/4 operation.

6.5.5 Perception

6.5.5.1 Perception will be required by ATO up to GoA4, taking the responsibility of capturing and characterizing the physical environment.

6.5.5.2 The harmonized operational concept for ATO up to GoA4 shall standardize all the requirements of Perception with respect to the physical environment.

6.5.5.3 This harmonization is necessary in order to have a single set of parameters within the Perception for the SERA, and standardized performance requirements.

6.5.6 Repository

6.5.6.1 As of 2025, the airgap between the CCS on-board and trackside is managed by [Subset-026] and [Subset-126] respectively for ERTMS/ETCS and ERTMS/ATO (GoA2).

6.5.6.2 With the introduction of Full ASTP, ATO up to GoA4, and Perception, the on-board CCS subsystem is needing additional data provided by the trackside CCS subsystem.

6.5.6.3 Therefore, the airgap between the on-board and trackside CCS subsystems needs to be further developed in order to support these new on-board needs.

6.5.6.4 So, to facilitate the handling of communication session management and handovers when crossing borders, and to centralize the retrieved trackside data for the different on-board clients, an on-board digital register is foreseen and identified as Repository.

6.5.6.5 Repository will manage the system interfaces version following the different TSIs, enabling backward and forward compatibility between CCS on-board and trackside when crossing borders.

6.5.6.6 Repository is currently being developed within Innovation Pillar Flagship Project 2 R2DATO, and in particular its communication session principles with the trackside CCS subsystem.

6.6 Stage 4: Target System (after CCS TSI 2032 release (approx. 2036))

6.6.1 Introduction

6.6.1.1 Stage 4 contains the phase out of GSM-R (FRMCS only, so no EDOR and no ADOR subsystems).

6.6.2 Euroradio Gateway (ERG)

6.6.2.1 The non-safety related functionality of the Euroradio protocol could be provided by an individual and exchangeable element called “Euroradio gateway”.

6.6.2.2 The “Euroradio gateway” serves to separate the non-safe communication through FRMCS from the safe automatic train protection through ETCS.

6.6.2.3 On the one hand an additional interface between ETCS/ATO and ERG has to be defined and maintained. On the other hand, the interface between ETCS/ATO and ERG is functionally already defined in [Subset-037] with [CCS TSI] 2023; if it is based on [Subset-147] then nearly nothing additional needs to be defined.

6.6.2.4 A strong argument in favor of a separate ERG is that there is only a standard communication and protocol for external communication, including PKI, update mechanisms, and potential future extensions like multi-paths. This standard is realized only once on board and is used by various applications, such as ETCS and ATO.

6.6.2.5 A con argument is that as long as GSM-R exists and the resource management for ETCS is partially implemented in [Subset-026], it is not necessary to have exchangeability of ERG (only after 2035). Additionally, there will be additional hardware costs for common ERG (ERG acts as OBapp agent) in the FRMCS only case (2036).

6.6.2.6 Two steps are planned:

1. Based on the separation of standards in [CCS TSI] 2023 ([Subset-026]/[Subset-037]) separate interoperability constituents could be achieved in one of the next TSI updates, e.g. CCS TSI 2029. This would allow the upgradeability for the non-safe part and security parts independent from the application due to a simplification of the approval based on a separation of SIL4 and basic integrity parts.
2. FFFIS which allows exchangeability. This is achievable in a CCS TSI for the time after GSM-R.

6.6.3 Cyber Security

6.6.3.1 For Cyber Security, update of cyber security requirements for interoperability with new ciphers for postquantum cryptography / hybrid scheme is likely.

6.6.3.2 Figure 11 illustrates the Security Zones for CCS TSI 2036 without GSM-R.

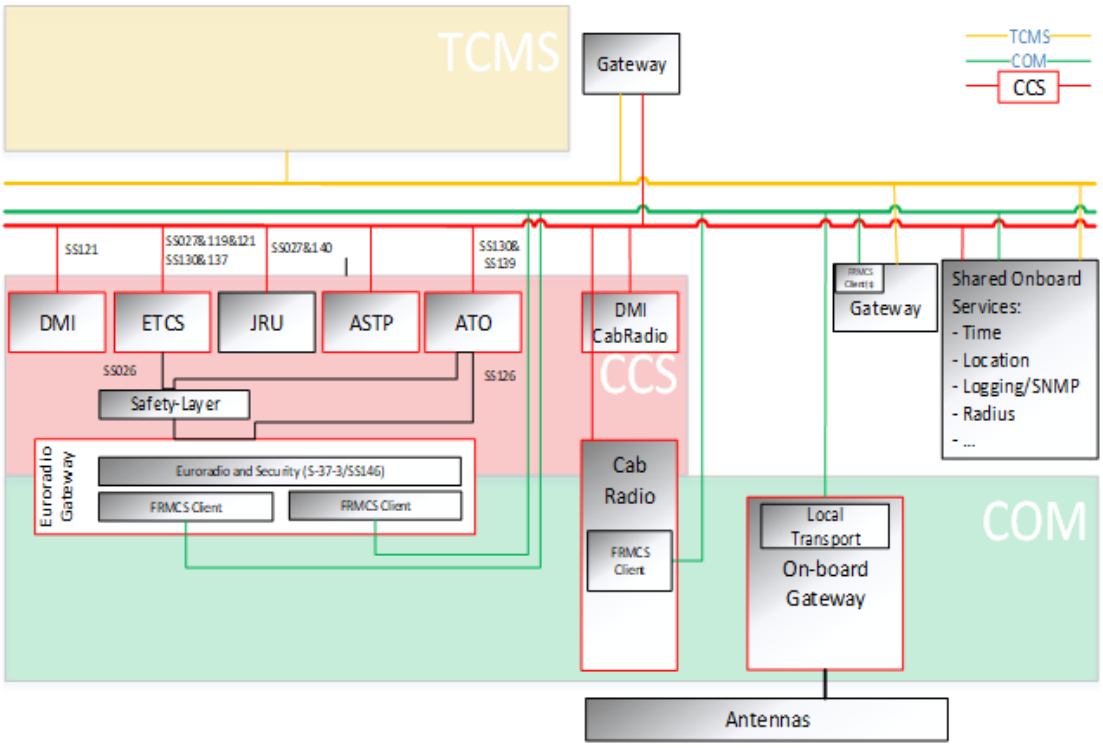

Figure 11 - Security Zones for TSI CCS 2036 [source: SP Train CS Domain: Summary of the Discussions for a Preliminary Bottom-up On-board CCS Architecture, v1.4, 24.11.2024]

7. SPECIFICATION STRUCTURE

7.1.1.1 The on-board CCS subsystem being a complex software-enabled engineered system including millions of lines of code, it requires a well thought through and strictly followed specification structure according to the following principles:

- Stream 1: Upstream work of mission and capabilities analysis, requirements development, functional decomposition, architectural design and system design of the on-board CCS subsystem;
- Stream 2: Recursive decomposition of the on-board CCS subsystem into logical components and subsystems and requirements allocation to these components or to surrounding subsystems (e.g. the rolling stock);
- Stream 3: Solution definition for the interfaces among the subsystems or their environment, which require full specification for interoperability, exchangeability or manageable integration;
- Functional risk and safety analysis and cyber security related threat and risk analysis for each stream.

7.1.1.2 Major parts of these principles have already been applied since many years, but recent discussions in the European railway committees for the on-board CCS subsystem architecture revealed a lack of understanding of the existing and required specification structure. Furthermore, the on-board architecture (including CCS on-board and the vehicle) still lacks an overall functional requirements specification.

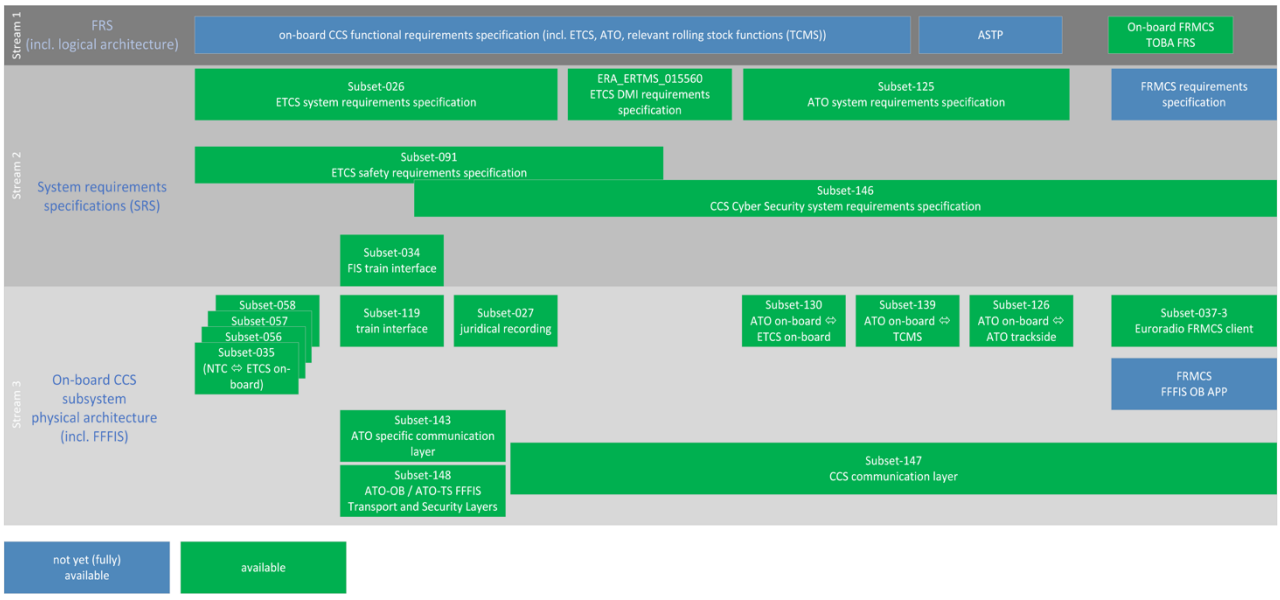

Figure 12 – Specification structure

7.1.1.3 Based on the current situation, the specification structure is shown in Figure 12 and shall be further developed by the sector stakeholders. This should be started with the creation of a functional requirements specification (FRS), which describes the complete set of functions of the on-board CCS subsystem.

7.1.1.4 The FRS shall also provide the apportionment of functions to components within an on-board CCS subsystem logical architecture. This will allow a facilitated management of roles and responsibilities of CCS on-board components over time. As this requires cross-functional knowledge, the specification can only be created by a team staffed from various railway areas and skilled in system architecture.

8. SHARED SERVICES

8.1 Priorities

8.1.1.1 According to Section 5.6.1.1, priority is the definition of the application layer (layer 7), requirements of which are defined by specific interface specifications ([Subset-119], [Subset-130], [Subset-139], and [FFFIS OBapp]).

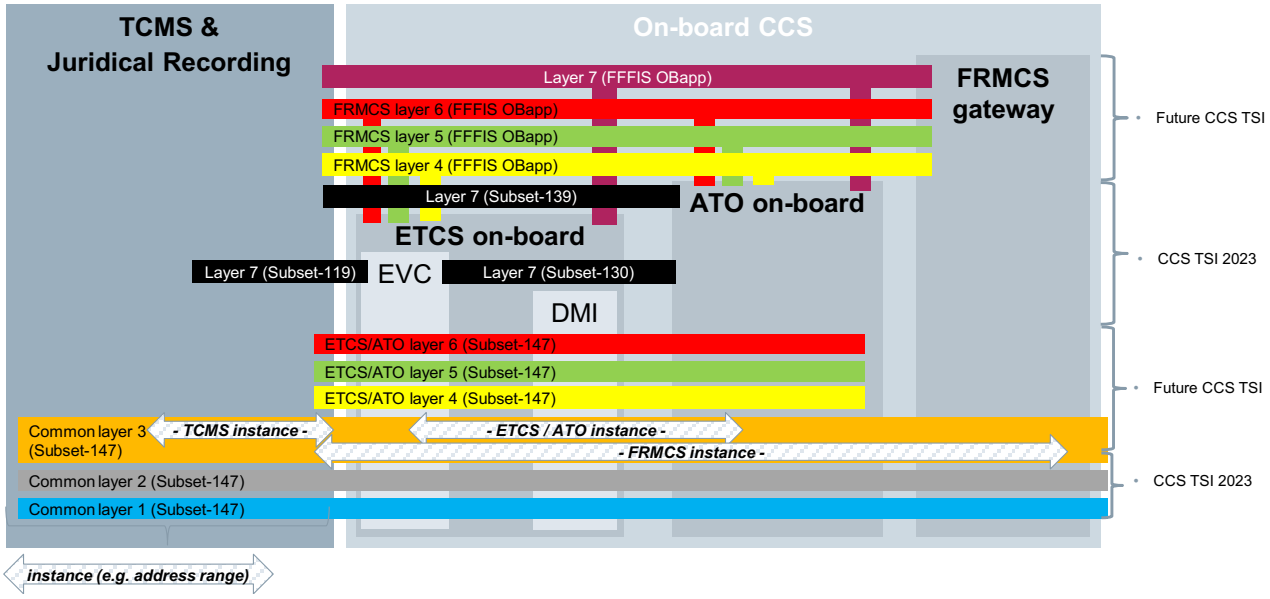

Figure 13 – Overview and specification of the full stack

8.1.1.2 The second priority is the definition of the layers 1 – 6 according to Figure 13. This is work in progress and currently under specification in ERJU Innovation and System Pillar for the layers 4 to 6 the situation is as follows:

- For FRMCS this will be defined by [FFFIS OBapp] and [Subset-037]. In combination with the specification of the layers 1 to 3, this will result in a full stack specification.
- For the interfaces…
  - ATO on-board – ETCS on-board
  - EVC – DMI
  - ETCS on-board – TCMS
  - ATO on-board – TCMS

…the full stack will be defined by the next revision of [Subset-147] (version 2).

8.1.2 Requirements for the layers 1 to 6

8.1.2.1 The specification of the requirements for the layers 1 to 6 will be provided by tasks with the ERJU Innovation Pillar and the System Pillar Train CS domain.

8.2 Shared services

8.2.1.1 The introduction of a unified communication platform in the form of the Ethernet CCS Consist Network opens up the possibility of deploying unified common central services, hereinafter referred to as shared services. Services can be accessed in a unified form via the protocols defined on the ECN.

8.2.1.2 Shared services can be used by several applications at the same time. However, shared services will not be assigned to an application. They are provided as part of the platform as cross-sectional topics. Shared services offer data management across applications. With the TTLS a service for the central provision of time and location with [Subset-147] has already been introduced. But shared services are not only intended to be used for the central provision of basic data, such as time and location, they are also used in the area of determination and provision of specific data on a number of other system aspects.

8.2.1.3 Useful aspects of the system, for which shared services can be used, include the areas of maintenance and repair of the onboard CCS subsystem as well as the authentication and access control of the system.

8.2.1.4 The definition and standardization of shared services thus comes more into focus when looking at the evolution of the onboard CCS subsystem. The Ethernet CCS Consist Network acts as the key for the system-wide use of unified common central services.

8.2.2 Shared services on various system aspects

8.2.2.1 When looking in the area of maintenance and repair of the system the important tasks of identifying and eliminating of faults have to be addressed. Issues have to be solved in relation to systematic errors, as they are typical in the case of software errors, as well as in relation to sporadic errors resulting from failures of hardware components.

8.2.2.2 This results in a spectrum for the provision of shared services to support the diagnostic capability of the system. Typical examples include diagnostic messages for failure of hardware parts of the system as well as logging and tracing for the traceability of system behavior for the analysis of software errors.

8.2.2.3 While hardware defects can easily be rectified by replacing the defective components, the elimination of software errors normally requires an update of the system software.

In case of performing software updates the tasks of providing, managing and deploying software have to be addressed.

8.2.2.4 The introduction of software updates is increasingly caused by changes of the requirements of the system, e.g. by increased security requirements or changes in rules and regulation. Thus, there are different reasons why the software of a system needs to be updated. Shared services can play a decisive role in various tasks here. This applies, for example, to the provision of the software on the vehicle, for example via remote download, the synchronization of the software of different systems on the vehicle or the coordination of the actual update of the software. Coordination of the introduction of software concerns both the consistent installation of software on all systems of a vehicle and the consistent introduction of software in relation to a fleet of vehicles. The central administration of the software provides information about the current software revision and allows a downgrade to an older software version in case issue have been detected after a new software roll-out. A revised certification and authorisation process is a prerequisite for remote downloads.

8.2.2.5 Another area of maintenance concerns the maintenance of the usability of the system. Changes in the system environment or operational requirements require adjustments of the system behavior. These are to be carried out as far as possible without software changes. To this end, the systems are being developed to a greater extent in a way that can be parameterized. The provision, management and insertion of configuration parameters is another aspect of central services.

8.2.2.6 In the area of authentication and access control, role-specific central access can be provided using modern identification technologies. The central administration allows the easy change of access concepts or role definitions.

8.2.3 Standardization

8.2.3.1 The standardization of shared services promotes the uniformity of functionality. Data is managed centrally and is available to several applications at the same time.

8.2.3.2 The standardization of shared services should not only cover the area of use of these services by the CCS onboard applications but should also include uniform interfaces for access by applications from outside, e.g. for the use of data by trackside diagnostic systems.

8.2.3.3 An extensive repertoire of shared services facilitates the integration of new applications into the overall system.

8.2.3.4 Since the data is usually stored in central databases, this allows the pre-processing or preparation of this data across applications, if necessary. This offers the ability to correlate and filter data across applications.

8.2.4 Summary

8.2.4.1 With the introduction of the ECN a platform was created that fosters the provision of cross-application functionalities via standardized methods and based on uniform protocols. These overarching functions or shared services should focus on the topics of diagnosis, maintainability, adaptability and access control.

8.2.4.2 Standardized shared services create a platform to support the integration and interaction of different applications of the onboard CCS subsystem and also eases data provision to external entities like track side management systems.

8.2.4.3 The definition of ‘Online Monitoring System’ is a first step towards a set of shared services provided for the onboard CCS subsystem via the ECN.

9. IMPACT ON THE CCS TSI

9.1 Introduction

9.1.1.1 As explained in the previous sections and especially the guiding principles in Section 5.7 the [CCS TSI] must be better prepared to release the authorisation process from unnecessary burden and to allow the introduction of non-safety-related enhancements without triggering a new authorisation.

9.1.1.2 The key points are the following:

- Separation of authorisation processes for non-safety-related and safety-related subsystems;
- Error corrections to increase cyber security shall be exempt from EC verification and authorisation;
- Integration of non-safety-related certified interoperability constituents into a vehicle shall be exempt from EC verification and authorisation;
- Exclusion of market failure mitigation (e.g. exchangeability) or market regulation from authorisation processes for vehicles.

9.1.1.3 The following sections describe suggestions for a change of the [CCS TSI] legal text to realise and fully benefit from the concept of “FRMCS readiness” (see Section 6.2.3). Anyway, the concept can also be transferred to other parts of the [CCS TSI], such as a simplified authorisation process for all non-safety-related subsystems of the on-board CCS subsystem.

9.2 Restructure of the interoperability constituents

9.2.1.1 To realise the key points for FRMCS readiness, first the interoperability constituent (IC) “ETCS on-board” shall be broken down. The [CCS TSI] shall not apportion the Euroradio communication (CFM layer) and safety layers (SFM layer) to one single interoperability constituent “ETCS on-board”, but to newly defined ICs.

9.2.1.2 A respective proposal is given below. The breakdown is motivated by the desire to be able to frequently update cyber security protection and non-safety-related functional modules without affecting safety related parts.

Interoperability constituent IC	**Characteristics**
ETCS on-board	RAMS

Interoperability constituent IC	Characteristics
	On-board ETCS functionality ETCS air gap interfaces *Interfaces (only new ones related to the example of FRMCS readiness)* • EuroRadio - Communication layer and coordination function • EuroRadio – Safety layer
EuroRadio - Communication layer and coordination function (CFM layer)	*Interfaces* ETCS on-board On-Board FRMCS
EuroRadio – Safety layer (SFM layer)	*Interfaces* ETCS on-board On-Board FRMCS

9.2.1.3 To avoid any negative impact on the installed base, the principle of grouping ICs shall remain. This will make sure that the ETCS on-board can principally be certified in the same manner as with the current [CCS TSI] (i.e. as one functional building block comprising the ETCS on-board, Euroradio CFM security and safety).

9.2.1.4 For the EC conformity assessment, the current processes will be kept, which means that all interoperability constituents (safety or non-safety related[1]) will be certified according to the current processes according to Decision [(EU) 2010/713] (module decision).

9.2.1.5 The modules according to Decision [(EU) 2010/713] should only be revised, concerning quality management approvals. All suppliers have certified quality management processes according to [ISO 9001] in place. Purchasers regularly witness the production plants of manufacturers. Hence, the additional quality management approvals for interoperability constituents by the notified bodies are regarded obsolete.

[1] A basic integrity or non-safety related IC (or part) means an IC (or part) which provides functions with a tolerable functional failure rate (TFFR) less demanding than 10E-5/h (basic integrity) or non-safety-related functions.

9.3 Modification of the EC verification principles

9.3.1.1 For the EC verification of the on-board CCS subsystem, the definition of parts (according to table 4.1 of the [CCS TSI]) shall be extended. Non-safety-related (or basic integrity) parts should be exempt from EC verification by the notified bodies.

9.3.1.2 UNISIG proposes a new principle of the conformity demonstration processes for the specific application in the regulations: integration of non-safety-related ICs into their operation environment (e.g. the vehicle) does not require third party assessment, when they carry an EC declaration of conformity. Requirements related to interoperability can be fully demonstrated within the IC's development process. Therefore, it is sufficient to focus on the IC when conformity against the [CCS TSI] is being assessed.

9.3.1.3 Hence, for non-safety related ICs the integration of these ICs in their environment should be performed solely under the responsibility of the system integrator's quality management system. It is not economically justifiable to involve third party assessment for these cases. Anyway, the system integrator remains responsible to draw up an EC declaration of verification also for those parts of the on-board CCS subsystem, which are not safety-related.

9.3.1.4 Formally, for non-safety related parts of the on-board CCS subsystem, the same spirit as for the module CA according to Decision [(EU) 2010/713] could be applied. UNISIG suggests creating a corresponding module for the subsystem (e.g. module SA) in an update of the EU Decision in the future (see also Section 9.2.1.5).

9.3.1.5 To realise the proposed concept, UNISIG suggests changing table 4.1 as follows.

Part	**Remark**	**Conformity assessment procedures**
Safety-related parts - mandatory		
Train protection	Safety related elements, such as ETCS-onboard, DMI	• ICs require EC declaration of conformity according to CB/CD, CH1; • EC verification according to modules SB/SD or SH1.
Non safety-related parts – mandatory		
Voice radio communication	Legacy (GSM-R) and new (FRMCS) Cab radio	• ICs require EC declaration of conformity according to CB/CD, CH1 or CA (SIM card); • No third-party assessment at subsystem level (manufacturer keeps evidence at the disposal of authorizing entity).
Data radio communication	Legacy (GSM-R) EDOR, Euroradio CFM and FRMCS Client	
Non safety-related parts – optional		

ATO	ATO functional module and ATO data communication	• ICs require EC declaration of conformity according to CB/CD, CH1 or CA; • No third-party assessment at subsystem level (manufacturer keeps evidence at the disposal of authorizing entity).

9.4 Modifications of the vehicle authorisation process

9.4.1.1 It is one of the key principles of the proposal, that adding non-safety-related elements or parts to an existing on-board CCS subsystem (installed base) must not trigger a new authorisation.

9.4.1.2 This can be avoided by using a tool already available in the current [CCS TSI]: The basic design characteristics (BDC).

9.4.1.3 BDC mean the parameters that are used to identify the vehicle type. Some BDC are relevant for authorisation and thus trigger a new authorisation once they are changed or once the extent of the change exceeds a certain threshold.

9.4.1.4 On-board CCS subsystem related BDCs are included in the [CCS TSI] in table 7.1 or in the [LOC&PAS TSI] in table 17a. These tables define also if a change of a vehicle in an area which relates to a BDC triggers a new authorisation or not.

9.4.1.5 UNISIG proposes in the [CCS TSI] to clearly distinguish the need for new authorisation on the safety relevance of a modification from the CCS point of view. The [CCS TSI] could do that by classifying BDCs accordingly in the table 7.1.

9.4.1.6 In relation to FRMCS, UNISIG proposes to change table 7.1 as follows:

1 TSI point	**2. Related BDC**	**3. Changes not impacting BDC (acc. to 15(1)(b) of Regulation [(EU) 2018/545])**	**4. Changes impacting BDC leading to a vehicle type version (acc. to 15 (1)c) of Regulation [(EU) 2018/545])**	**5. Changes impacting BDC leading to a vehicle type variant(15 (1)d) of Regulation [(EU) 2018/545] (triggering a new authorisation)**
Train protection - On-board	Set of specification of Annex A	Not Applicable	Not Applicable	Use another Annex A set of specification

1 TSI point	2. Related BDC	3. Changes not impacting BDC (acc. to 15(1)(b) of Regulation [(EU) 2018/545])	4. Changes impacting BDC leading to a vehicle type version (acc. to 15 (1)c) of Regulation [(EU) 2018/545])	5. Changes impacting BDC leading to a vehicle type variant(15 (1)d) of Regulation [(EU) 2018/545] (triggering a new authorisation)
ETCS functionality (safety related part)	(ETCS baseline)			
	On-board ETCS implementation	Fullfilling all conditions in point 7.2.1a.2 (change of realization)	Not Applicable	Not fulfilling all the conditions in point 7.2.1a.2 (Functional change).
Data radio communication applications for ETCS	Radio Baseline	Use another Baseline fulfilling all the conditions in point 7.2.1a.3.	Use another Baseline not fulfilling all the conditions in point 7.2.1a.3	Not Applicable
	Data communication for ETCS implementation	Fulfilling all the conditions in point 7.2.1a.	Not fulfilling all the conditions in point 7.2.1a.3.	Not Applicable

9.4.1.7 This classification is without prejudice to related changes on a vehicle as defined by the [LOC&PAS TSI] in table 17a, e.g. a change could lead to an extension of the total vehicle mass of more than 10%, so that it triggers a new authorisation, although not required by the [CCS TSI]'s BDC. Therefore, it is – for the avoidance of new authorisations - fundamental to also analyse and anticipate the impact on vehicles if it comes to an upgrade to FRMCS (at least as a replacement for voice cab and ETCS data only radio).

10. THE SYSTEM ARCHITECTURES

10.1 Introduction

10.1.1.1 This section shows the architectural drawings based on the analysis and guiding principles of the previous sections.

10.1.1.2 The target on-board CCS subsystem cannot be reached in one step but evolution steps for harmonisation are needed.

10.1.1.3 The evolution steps have to be linked to the TSI releases also in case of SP standards in order to avoid too many steps and to have one consistent on-board CCS subsystem architecture per TSI.

10.1.1.4 The following TSI CCS releases are assumed (for details see chapter 6):

- Stage 1: Short Term - next major CCS TSI update (approx. 2028/2029) - TSI update mainly for FRMCS v3, Ethernet CCS Consist Network (SS-147) and Cyber Security
- Stage 2: Mid Term - after CCS TSI 2028/2029 release (approx. 2030) - next TSI update for enhancements and the next upgrade to higher ETCS/ATO/Radio System Versions
- Stage 3: Long Term - after CCS TSI 2030 release (approx. 2032) - TSI update including ATO GoA 3/4; planning to phase out GSM-R
- Stage 4: Target System - after CCS TSI 2032 release (approx. 2036) - Decommissioning of GSM-R

10.1.1.5 Under these conditions the following evolution steps and alternatives are drafted:

Topic	Stage 1	Stage 2: Target 1	Stage 3: Target 2	Stage 3: Target 2/A, Alternative 1	Stage 3: Target 2/A, Alternative 2	Stage 4: Alternative 1	Stage 4: Alternative 2
S-147, v2.0 – STIP 68	X	X	X	X	X	X	X
FRMCS V3 – STIP 62	X	X	X	X	X	X	X
TI Enhanc. incl. TL – STIP 71/73		X	X	X	X	X	X
ATO GoA 1/2 Enhanc.		X	X	X	X	X	X
IF TDS-ETCS On-board – STIP 69			X	X	X	X	X
Subsystem ASTP – STIP 29/30			X	X	X	X	X
IF ASTP – ATO OB for 3D information – STIP 29/30					X		X
Multi Display System – STIP 70			X	X	X	X	X
ATO GoA 3/4 – STIP 20/21/23/27				X	X	X	X
Subsystem Perception – STIP 22				X	X	X	X
Subsystem Repository – STIP 67			X	X	X	X	X
IF FRMCS/Rep.			X	X	X	X	X
FRMCS only						X	X
IF OMS – ASTP					X		X
Euroradio GW							X

Table 1 : Overview on CCS On-board Topics for Architecture Evolution Steps with Alternatives

10.2 Stage 1 – next major CCS TSI update (approx. 2028/2029)

10.2.1.1 Stage 1 contains the evolution step for TSI CCS 2028/2029 including the update of the Ethernet CCS Consist Network with SS-147, v2 - STIP 68

10.2.2 Architecture

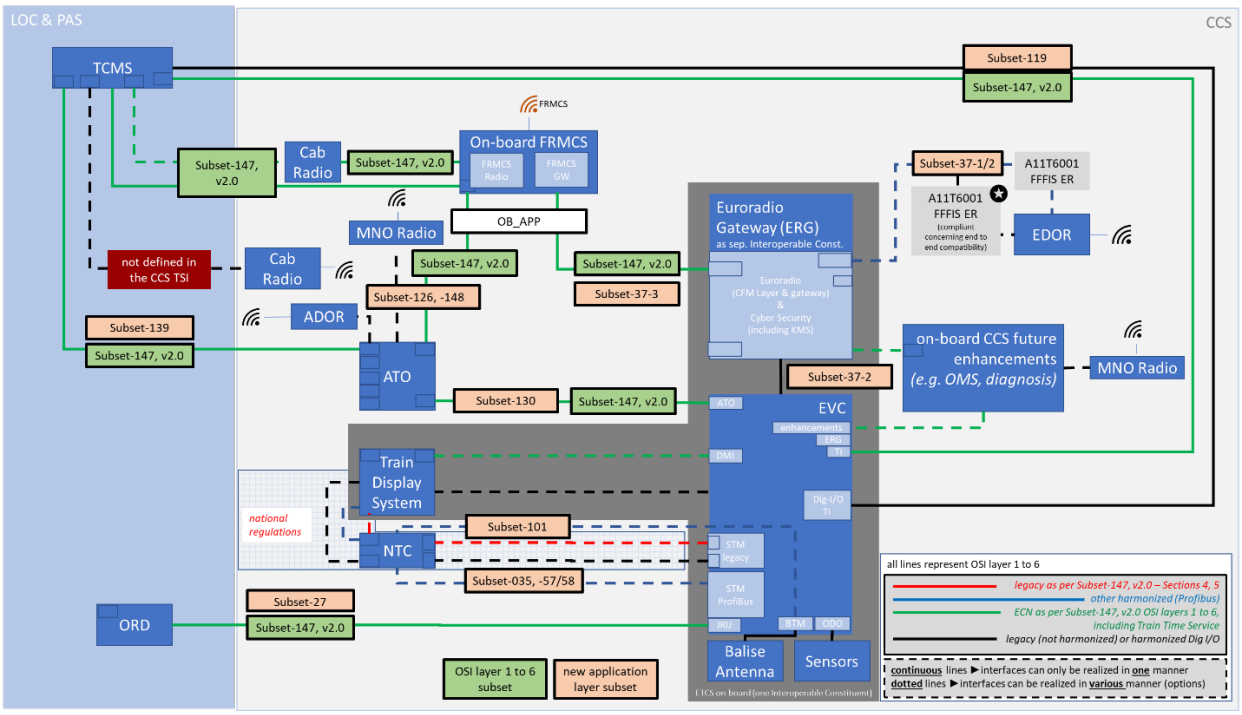

Figure 14: Draft CCS On-board Architecture TSI CCS 2028

10.3 Stage 2: after CCS TSI 2028/2029 release (approx. 2030)

10.3.1.1 Stage 2 contains:

- The update for FRMCS - STIP 62
- TI Enhancement (S-034/-119/-139) – STIP 71
- TI Adaptation for integrity handling and train length / overall consist length (S-034/-119) – STIP 73
- Enhancements for ATO GoA 1/2 and ETCS on-board

10.3.2 Architecture

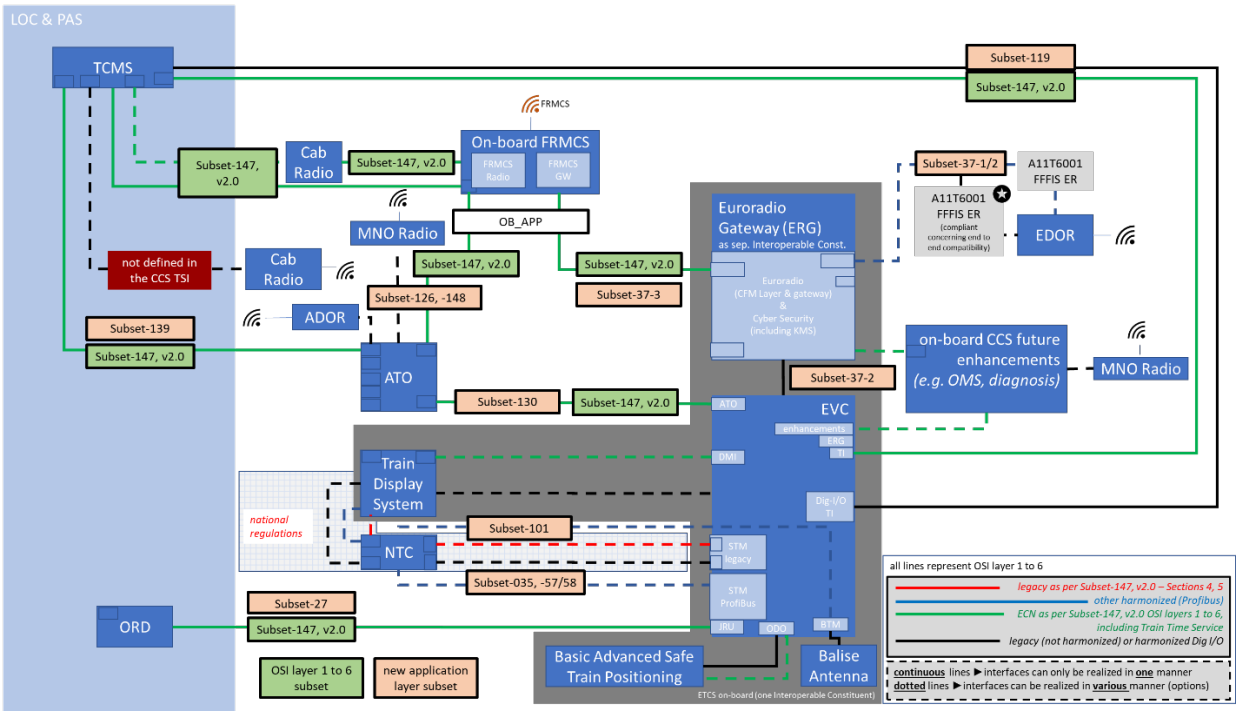

Figure 15: Draft CCS On-board Architecture CCS TSI 2030

10.4 Stage 3: after CCS TSI 2030 release (approx. 2032)

10.4.1.1 Stage 3 contains:

- On-board Repository - STIP 67
- Harmonised Full ASTP - STIP 30

10.4.1.2 Harmonised Multi Display System - STIP 70Alternative 1 contain the evolution step for CCS TSI 2032 incl. in addition

- Target A for ATO GoA 3/4 for all alternatives - STIP 20, 21, 22, 23, 27
- ATO-OB as per SUBSET-125 v1.0.0 is renamed into Automatic Driving Module (ADM, defined in a new version of SUBSET-125) which supports GoA2 operation.
- Automatic Processing Module (APM) and Perception are added alongside ADM to support GoA3/4 operation.
- ADM has no interfaces to APM and to PER which facilitates scalability and modularity of the on-board from GoA2 to GoA3/4.

10.4.1.3 Alternative 2 contains the evolution step for TSI CCS 2032, Target A incl. in addition

- a direct connection with "On-board FRMCS" for receiving the map data.

- a connection of OMS with ASTP to be able to tag monitoring information with 3D coordinates.

10.4.1.4 Description of the Alternatives:

- Target 2/A includes ATO GoA 3/4 while Target 2 includes ATO GoA 1/2, only.
- There is the agreed UNISIG position that ASTP shall provide only Fixed Point positioning output. So, ETCS is needed to calculate and provide the Train Front End info. Otherwise other subsystems might use different info then ETCS assumes and ASTP would become more complex as it would need ETCS functionality to calculate the Train Front End correctly. For 3D position a further analysis is needed if it shall be provided by the ETCS on-board or the ASTP. Therefore, the interface between ASTP and ATO-OB is considered as alternative.
- Perception: Basic ASTP is not enough to match the performance requirements of Perception (6D and precision expectations). Therefore, a combination is considered.
- OMS should probably have a connection with ASTP to be able to tag monitoring information with 3D coordinates. This interface is considered in Alternative 2.

10.4.1.5 The on-board Repository introduces changes in the different architectures of the stage 3:

- In stage 3, target 2:
  - The ATO-OB as per SUBSET-125 v1.0.0, is managing its communication with a CCS trackside, as per SUBSET-126 v1.0.0.
  - The Repository, gathering the information from CCS trackside for absolute positioning, is managing its communication with a CCS trackside, as per a new version of SUBSET-126 (e.g. v2.0.0).
  - This target enables the deployment of ASTP (combined with Repository) in an on-board already equipped with ATO-OB and without the need for an update of ATO-OB.
  - An interface between Repository and ETCS-OB is introduced, and will support remote automatic ETCS data entry (preparation step for ATO GoA3/4).
- In stage 3, targets 2/A (all alternatives), ATO-OB as per SUBSET-125 v1.0.0 is replaced by ADM (new version of SUBSET-125), as part of ATO up to GoA4:
  - ADM is no more managing its communication with a CCS trackside, as it gets the Journey Profile and Segment Profile information from Repository,
  - Repository manages the communication with a CCS trackside, based on a new version of SUBSET-126 (e.g. v3.0.0).
  - Repository becomes the centraliser of the retrieved CCS trackside data for distribution to all CCS on-board clients, thus avoiding redundancy of data,

- ETCS keeps its own communication with the CCS trackside as specified in SUBSET-026.

- Repository remains backward compatible with previous versions of SUBSET-126. Which means that an on-board of stage 3 (and stage 4) can run in GoA2 in a GoA2 area equipped with a CCS trackside as per SUBSETs -125 and -126 v1.0.0.

10.4.2 Architecture

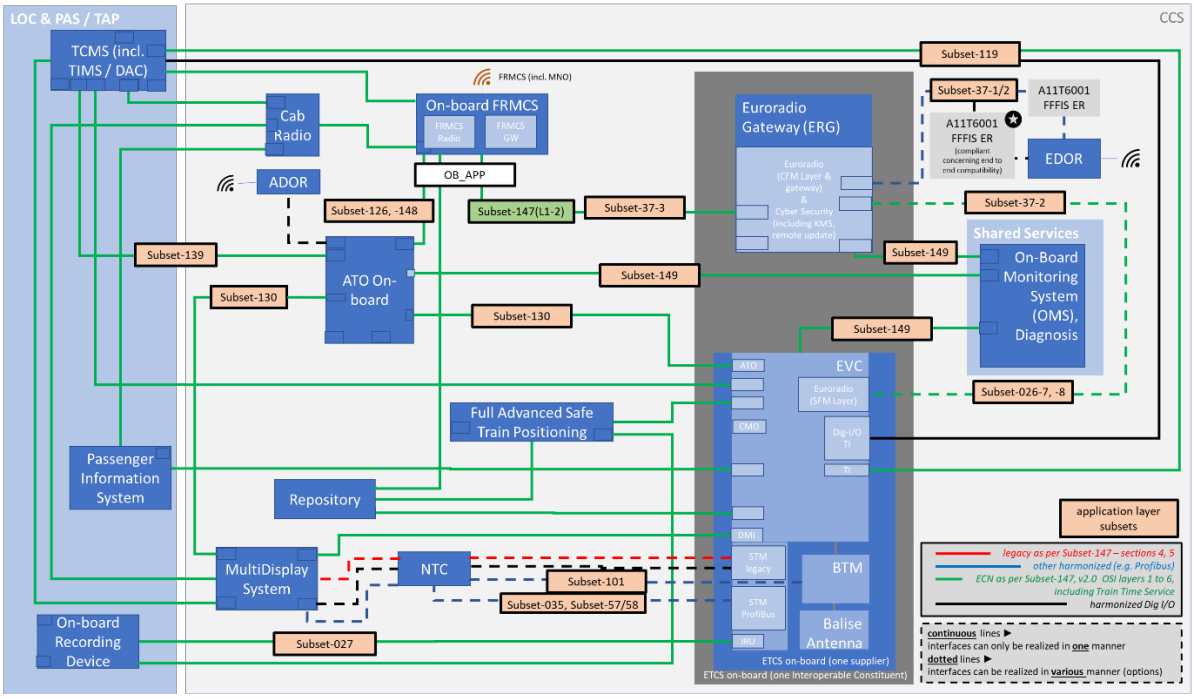

Figure 16: Draft CCS On-board Architecture TSI CCS 2032 (Target 2)

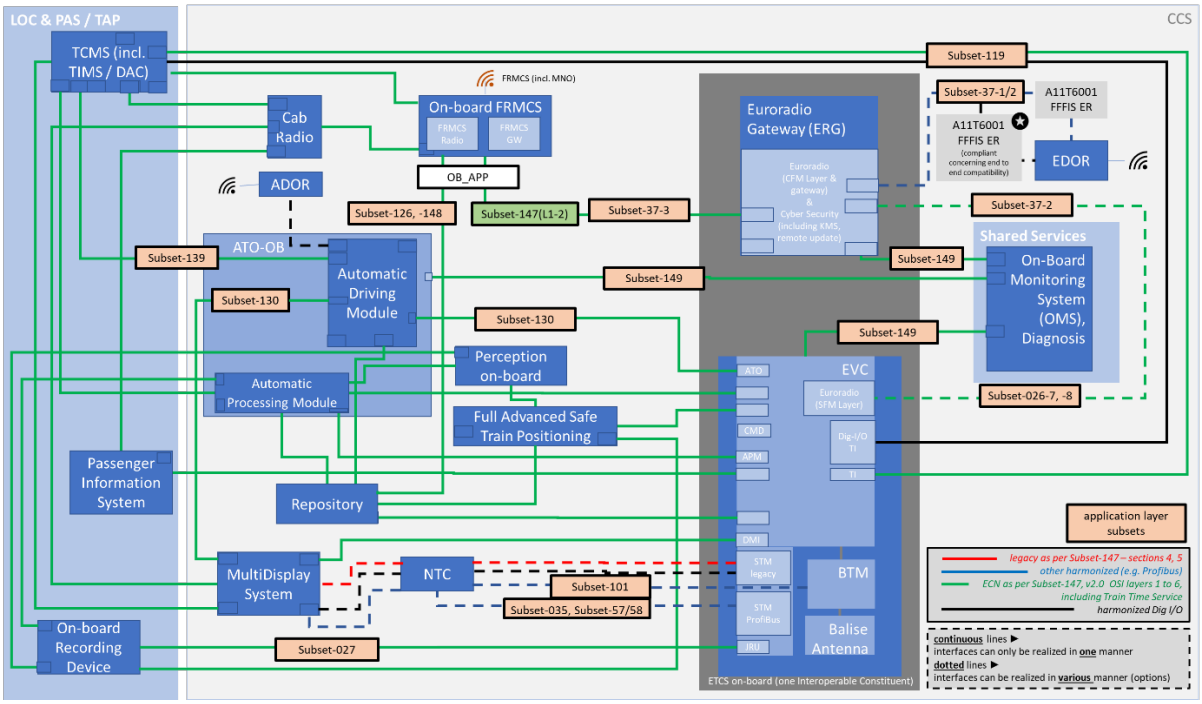

Figure 17: Draft CCS On-board Architecture TSI CCS 2032 (Target 2/A, Alternative 1)

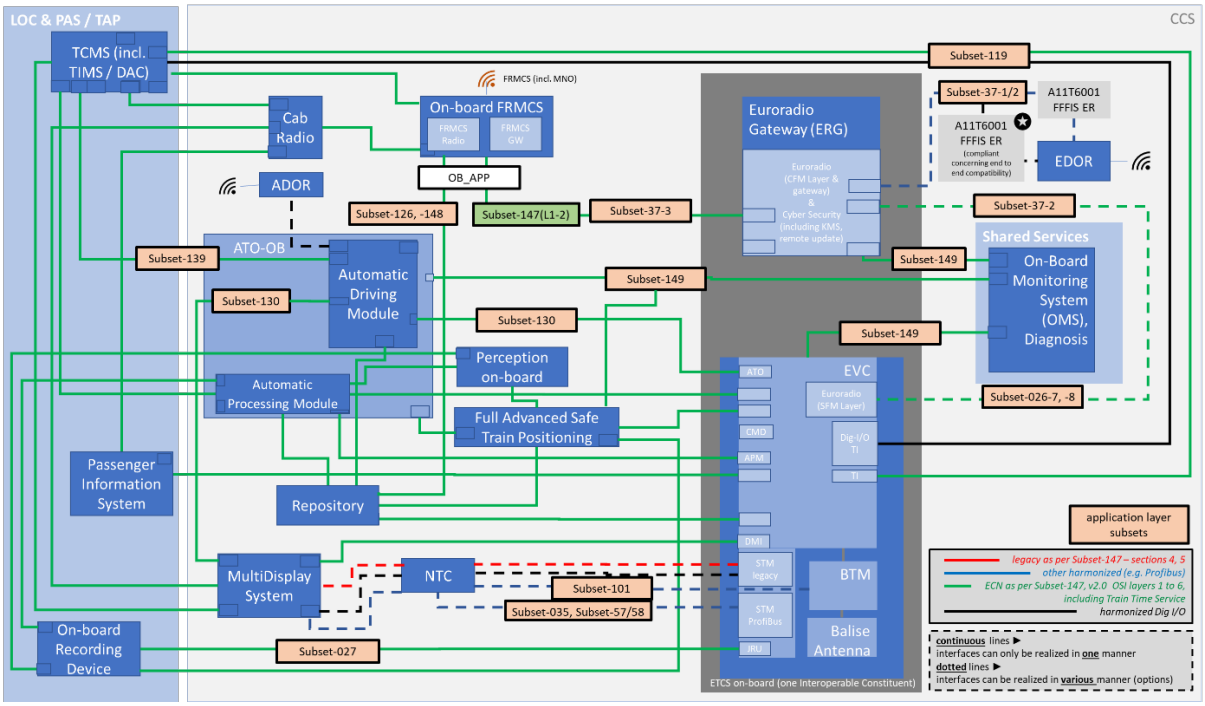

Figure 18: Draft CCS On-board Architecture TSI CCS 2032 (Target 2/A, Alternative 2)

10.5 Stage 4: after CCS TSI 2032 release (approx. 2036)

10.5.1.1 Stage 4 contains the evolution step for CCS TSI 2036 including for all alternatives the phase out of GSM-R (FRMCS only, so no EDOR and no ADOR subsystems).

10.5.1.2 Alternative 2 contains a separate harmonised subsystem for the Euroradio Gateway (ERG).

10.5.1.3 Alternative 2 contains in addition

- a direct connection with "On-board FRMCS" for receiving the map data.
- a connection of OMS with ASTP to be able to tag monitoring information with 3D coordinates.

10.5.1.4 Description of the Alternatives:

- There is an ongoing discussion if there is an own subsystem for Euroradio shall be introduced or not as soon as GSM-R is out phased. The own subsystem is considered in Alternative 2.
- OMS should probably have a connection with ASTP to be able to tag monitoring information with 3D coordinates. This interface is considered in Alternative 2.

10.5.2 Architecture

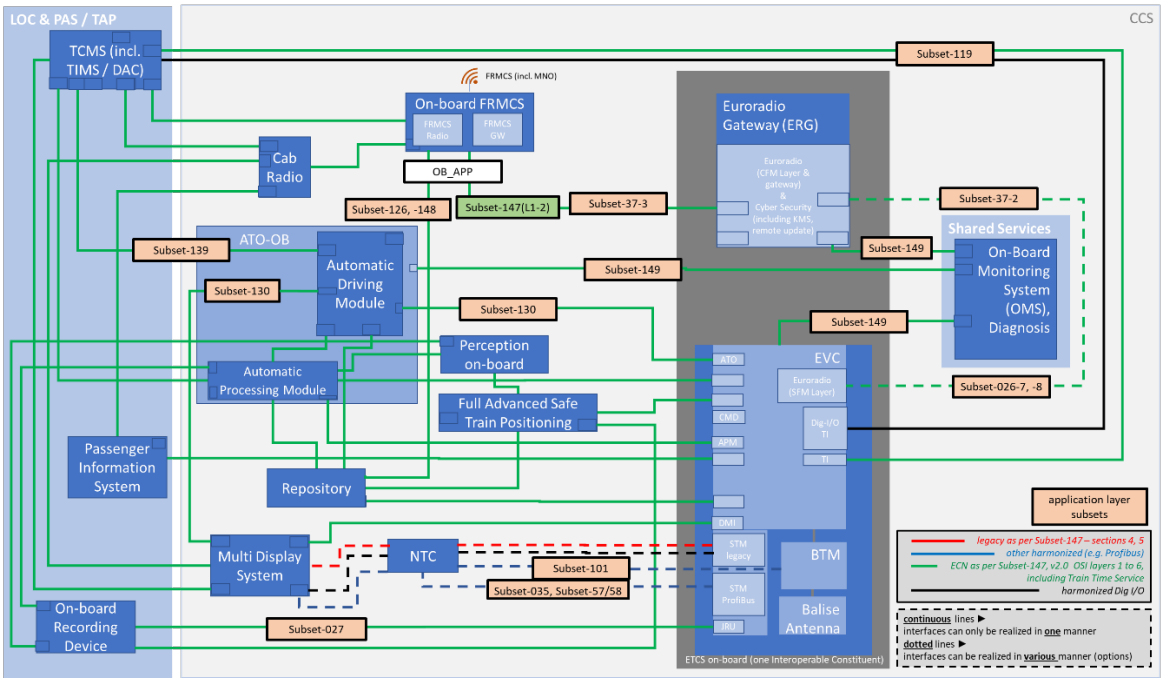

Figure 19: Draft CCS On-board Architecture TSI CCS 2036 (Target 2/A, Alternative 1)

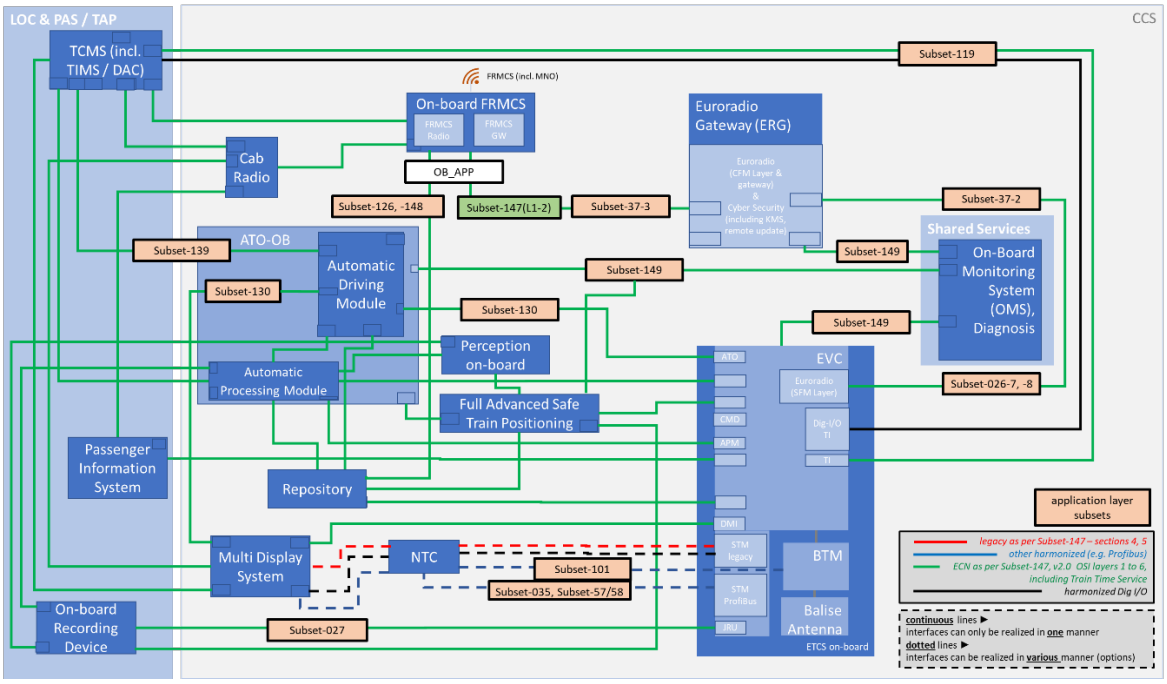

Figure 20: Draft CCS On-board Architecture TSI CCS 2036 (Target 2/A, Alternative 2)

11. REFERENCES

ID	Name
[(EU) 2010/713]	COMMISSION DECISION of 9 November 2010on modules for the procedures for assessment of conformity, suitability for use and EC verification to be used in the technical specifications for interoperability adopted under Directive 2008/57/EC of the European Parliament and of the Council
[(EU) 2016/797]	DIRECTIVE (EU) 2016/797 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 May 2016 on the interoperability of the rail system within the European Union
[(EU) 2018/545]	COMMISSION IMPLEMENTING REGULATION (EU) 2018/545 of 4 April 2018 establishing practical arrangements for the railway vehicle authorisation and railway vehicle type authorisation process pursuant to Directive (EU) 2016/797 of the European Parliament and of the Council
[CCS Features]	SPT2TrainCS/SPT2TRAIN-3718D1_ CCS Features Indivisible for deployment,12Deliverable1_CCS_Features_Packages_Indivisible_for_Deployment, 08.07.2024, v0.4
[CCS TSI]	COMMISSION IMPLEMENTING REGULATION (EU) 2023/1695 of 10 August 2023 on the technical specification for interoperability relating to the control-command and signalling subsystems of the rail system in the European Union and repealing Regulation (EU) 2016/919
[ERA_ERTMS_015560]	ETCS Driver Machine Interface
[FFFIS OBapp]	Interface specification for the FRMCS on-board applications
[IEC61375-3-4]	Electronic railway equipment - Train communication network (TCN) - Part 3-4: Ethernet CCS Consist Network (ECN) March 2014
[IP ASTP Design]	D22.1 – ASTP Report on Common Overall Design and Architecture
[ISO 9001]	Quality management systems - Requirements (ISO 9001:2015)
[LOC&PAS TSI]	COMMISSION REGULATION (EU) No 1302/2014 of 18 November 2014 concerning a technical specification for interoperability relating to the 'rolling stock — locomotives and passenger rolling stock' subsystem of the rail system in the European Union *If followed by a year, this reference can also refer to a previous or future version of the document.*
[OPE TSI]	COMMISSION IMPLEMENTING REGULATION (EU) 2019/773 of 16 May 2019 on the technical specification for interoperability relating to the

ID	Name
	operation and traffic management subsystem of the rail system within the European Union and repealing Decision
[SP Granularity Principles]	Granularity Concepts and Principles, F. Bitsch et al., EURAIL-internal, Delivery of System Pillar Domain SPT2-Architecture and Release Coordination, ARC-D2.3, v. 4.0, 16.11.2024
[STIP]	SPT2TrainCS/SPT2TRAIN-3716EU-RAIL Standardisation and TSI Input Plan (STIP), 02.07.2024, v1.0 final
[Subset-026]	ERTMS/ETCS – System Requirement Specification
[Subset-034]	ERTMS/ETCS - Train Interface FIS
[Subset-035]	ERTMS/ETCS - Specific Transmission Module FFFIS
[Subset-037]	ERTMS/ETCS – Euradio FIS *The Subset was split into three parts in the future. Part 1: Euroradio safety FIS, Part 2: Coordination Function, Part 3: FRMCS client.*
[Subset-041]	Dimensioning and Engineering rules
[Subset-080]	Train Interface FMEA
[Subset-119]	ERTMS/ETCS - Train interface
[Subset-120]	ERTMS/ETCS - Train interface – Safety analysis
[Subset-125]	ERTMS/ATO System Requirements Specification
[Subset-126]	ATO-OB / ATO-TS FFFIS Application Layer
[Subset-130]	ATO over ETCS – ATO-OB / ETC-OB FFFIS – Application layer
[Subset-139]	ATO over ETCS – ATO-OB / TCMS Interface Specification - FFFIS
[Subset-140]	ATO over ETCS – ATO-OB / ORD FFFIS – Application layers
[Subset-143]	ATO over ETCS – Interface specification – communication layers for on-board communication
[Subset-147]	ERTMS/ETCS and ATO over ETCS FFFIS part: Communication layers
[Subset-148]	ATO-OB / ATO-TS FFFIS Transport and Security Layers
[Subset-149|	Online monitoring system