Control-Command and Signalling Subsystems - Testing Framework within the APIS Process

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Abstract – **This article focuses on the testing framework of the CCS SS that are part of the Railway System, within the APIS process. Testing is part of verification and validation to support product development, verification and validation of technical compatibility and safe integration. Based on a study implementation the highlights of the testing within the APIS legal framework are pointed out and issues are discussed and analysed.**

Keywords – **Railway system, CCS, TSI, Authorisation for Placing in Service**

I. Introduction

The Interoperability Directive 2008/57/EC [1] sets the legal framework for the authorisation for placing in service (APIS) of the railway structural subsystems and vehicles. It also introduces the technical specifications for interoperability (TSI). The TSIs specify the essential requirements for each subsystem and the functional and technical specifications to be met by these subsystems and their interfaces. According to Directive 2008/57/EC article 15, *"Member States (MSs) shall take all appropriate steps to ensure that these subsystems may be placed in service only if they are designed, constructed and installed in such a way as to meet the essential requirements concerning them when integrated into the rail system"*. In particular, the MS has to check technical compatibility and safe integration before subsystems may be placed in service. The Commission Implementing Regulation (EU) No 402/2013 [8] on the common safety method for risk evaluation and assessment (CSM-RA) describes the risk management process to be implemented in case of any change to the railway system. The Commission Recommendation 2014/897/EU [5] clarifies the procedure for APIS of structural subsystems and vehicles as set out in [1].

APIS is one of the activities supporting the development of an integrated, safe and interoperable railway system in the European Union (EU), particularly in the field of cross-acceptance of railway subsystems, i.e. mutual recognition of authorisations for the placing in service of railway vehicles.

Testing is part of verification and validation to support product development, subsystem integration, subsystem verification, and validation of technical compatibility and safe integration.

Currently many issues arise with the different CCS subsystem (CCS SS) definitions and the relevant scope of the final testing phase under the legal framework in force.

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II. Control-command and Signalling subsystem definition

Within the European legal framework for interoperability the Control-command and Signalling subsystem is one of the structural subsystems specified in [1] and is divided into track-side (TS) and on-board (OB) parts. In Annex II to [1] the CCS SS is defined as *'all the equipment required to ensure safety and to command and control movements of trains authorised to travel on the network'*. The features of the CCS subsystems are [3]: the functions that are essential for the safe control of railway traffic, and that are essential for its operation, including those required for degraded modes; the interfaces; the level of performance required to meet the essential requirements. The CCS TSI specifies only those requirements which are necessary to assure the interoperability of the EU rail system and compliance with the essential requirements.

The CCS TSI [3] specifies the following TS-CCS parts: *trackside train protection (class A)*; *trackside radio communication (class A), train detection (as interface requirements, to ensure compatibility with rolling stock)*, and OB-CCS parts: *on-board train protection (class A)* and *on-board radio communication (class A)*. The Class A train protection system is ERTMS/ETCS whilst the Class A radio system is GSM-R. For Class A train detection this TSI specifies only the requirements for the interfaces with the other subsystems [3]. The scope of TSI CCS subsystem parts is shown on Figure 1 below.

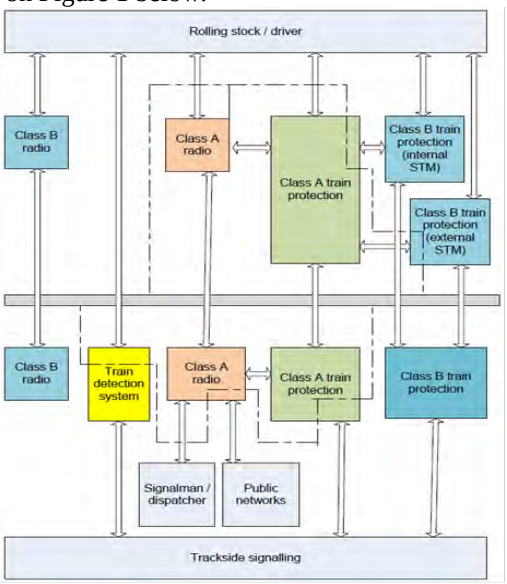

Fig. 1. Scope of TSI Control-Command and Signalling [4]

III. APIS PROCESS AND TESTING

Authorisation for placing in service process

Commission Recommendation 2014/897/EU [5] defines the APIS of a subsystem as '*the recognition by the Member State that the applicant for this subsystem has demonstrated that it meets, in its design operating state, all the essential requirements of Directive 2008/57/EC when integrated into the rail system'.*

In principal Directive 2008/57/EC [1] regulates the technical characteristics of the railway subsystems and vehicles and the process of their authorisation for placing in service and Directive 2004/49/EC [2] regulates the processes of their use, operation and maintenance after the authorisation. After a subsystem is placed in service, care should be taken to ensure that it is operated and maintained in accordance with the essential requirements relating to it. Under [2], responsibility for meeting these requirements lies, for their respective subsystems, with the infrastructure manager (IM) or the railway undertaking (RU). The National Safety Authority (NSA) acts, on behalf of the MS to grant the APIS. Some NSAs also grant a temporary authorisation or authorisation for operation on specific lines, with restrictions.

Testing process

The goal of the testing process within an APIS could be distinguished in between interoperability requirements for obtaining evidences for operation under full operational conditions and the evidences that ensure the technical compatibility and the safe integration of the CCS subsystems.

According to the CCS TSI the main target is "*A certified train that can run on certified lines with only a few additional checks and tests (corresponding class B systems)*". To achieve such target situation the following parameters shall be checked in accordance with [1]: the technical compatibility of these subsystems with the system into which they are to be integrated, and the safe integration of these subsystems in accordance with Articles 4(3) and 6(3) of [2].

Testing process of the CCS SS under the different definitions scope is analysed below and presented on Figure 2.

Testing process within an APIS for CCS SS

In general, according to [5], the only tests that may be required for authorization, which have to be performed before the authorization for placing in service and which requires the involvement of an assessment body, should be the tests which are [5]:

- explicitly specified in the TSIs, modules, and, where relevant, in national rules;
- defined by the applicant for demonstrating the compliance with the requirements of the TSIs and/or national rules;
- defined in other EU legislation, or
- defined by the applicant, in accordance with the application of CSM RA (i.e. safe integration between the elements composing a subsystem and/or safe integration between subsystems that constitute a vehicle or a network project).

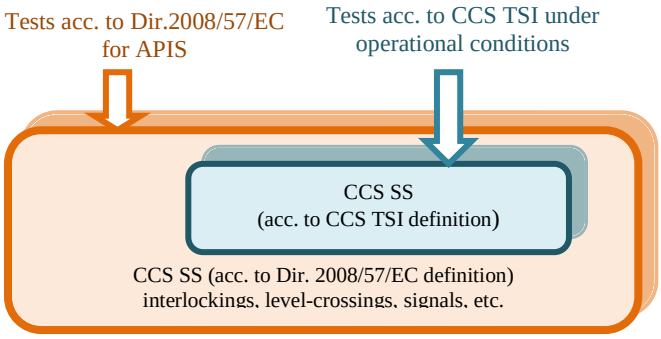

Fig. 2. Scope of the CCS subsystems tests

Table I summarises the participants and their roles within the testing process, according to the Commission Recommendation 2014/897/EU [5].

TABLE I
ROLES AND TESTING

Roles / Tests (acc. to [5])		Applicant	NoBo	DeBo	AsBo
Explicitly specified in the TSI		X	X	NA	NA
Modules		X	X	NA	NA
National rules (where relevant)		X	NA	X	X
Defined by the applicant	Demonstrating compliance with TSI/NR	X	X	X	NA
	CSM-RA application	X	X see Table 6.2 and 6.3 [3]	NA	X
Defined in other EU legislation		X	X see [1]	NA	NA

Testing and Notified Bodies

Depending on the modules used in accordance with [6], testing responsibility rests with the different parties involved in the EC verification and assessment procedure. Table II below presents the testing execution responsibilities.

TABLE II
TESTING AND NOTIFIED BODIES

Module	Responsibility		
	Applicant	NoBo	Other Body
SB+SD	NO	X	NO
SB+SF	NO	X	NO
SG	X (if stated in the TSI but not valid for the CCS TSI)	X (as overall responsibility)	X
SH1	X	NO	X (if on behalf of the applicant)

Using SB+SF or SB+SD modules the tests fall under the Notified Body (NoBo) responsibilities with the related execution. Using SG module the tests results fall under the NoBo responsibilities but the execution is also possible by other bodies (different from the NoBo) under comparable conditions (previously recognised by the NoBo assessing their accreditations/recognitions). Using SH1 module the responsibilities of the test results as well as the execution fall under the applicant. Tests can be also carried out by other appointed bodies on behalf of the applicant. The NoBo does not need to perform any special recognition. A NoBo assesses the compliance with the relevant TSI requirements using appropriate testing through the QMS assessment.

Some inputs

- ✓The selection of the certification module is crucial in order to define roles and responsibilities of testing;
- ✓When a module including testing is selected it is beneficial to agree a test plan between the applicant and the NoBo including the definition of roles and responsibilities;
- ✓A major involvement of the Applicant in a testing phase (who knows really what to test);
- ✓The amount of test cases could be increased but the operational scenarios should be the real one;
- ✓Sometimes a NoBo has not in-house testing capabilities and external bodies have to be hired causing a time and cost extension and such entity(ies) need to be recognised by the NoBo in accordance with its internal procedure or the accreditation standards.
- ✓The separation of tests in and out the scope of an APIS should be clear (e.g. tests needed by RU to establish train-route compatibility before using a vehicle type or new subsystem on a particular route).

IV. RESULTS FROM THE ANALYSIS

The main findings made out of the analysis of the testing framework within the APIS process could be summarised, as follows:

- ✓The scope of the CCS SS definition is different within the legal interoperability documents that specify both trackside and on-board CCS subsystems, namely:
  - The definition of CCS subsystems given in the CCS TSI covers the **basic parameters** in relation with such TSI (i.e. class A systems and their interfaces);
  - The definition of CCS subsystems given in Annex II of the [1]covers **an extended scope** (including in principle class B systems and other safety-related systems – interlockings, level-crossing systems, block systems, signals, etc.);
- ✓In general APIS covers a subsystem and therefore the definition of Annex II of the Directive 2008/57/EC should be the reference definition. Furthermore, an APIS requires **only the essential requirements** in [1] to be met through the use of TSIs.
- ✓In practice when the CCS TSI refers to final tests under full operation conditions it addresses the **basic parameters** within the TSI.

Critical issues:

- ➢An APIS is granted to a structural subsystem having a wider scope (including all safety-related equipment) as intended in [1];
- ➢CCS TSI does not cover the whole scope of CCS SS but the interoperability aspects only;
- ➢A question arises: Should the parts not covered by the CCS TSI be tested within the APIS process?

The Commission Recommendation 2014/897/EU [5] says "NO" but this is not the current practice in the Member States.

- ✓The use of conditional statement in [5] like *may be* for *"the only tests that may be required for authorization"* provides a certain degree of freedom;
- ✓The conformity assessment modules [6] addressed only the responsibility for making required tests but what kind of tests is not specified;
- ✓The requirement for tests [5] to be executed under national rules, where relevant, is too generic and leaves ambiguities (i.e. national technical rules or national safety rules);
- ✓Railway specific tests defined in other EU legislation and the responsible party for them are difficult to be controlled due to the wide-range scope;
- ✓The requirement for tests defined by the Applicant also provides a certain degree of freedom depending on the real aim of the Applicant - to verify only the TSI requirements, the national requirements where relevant or something else;

Critical issues:

- ➢Some actors are missing in the testing framework within the APIS: An Assessment Body (e.g. the NoBo according to the duties and responsibilities given through the selected conformity assessment module), IM or RU, NSA. However, in general, such entities might be part of a testing process for APIS.
- ➢In case of an APIS process includes also other actors how could the CCS parts not subject to interoperability be tested? Commission Recommendation 2014/897/EU excludes them but these parts can be considered in the CSM–RA application.

V. EVOLUTION OF THE TESTING FRAMEWORK WITHIN THE APIS PROCESS

In our days, evidence showing that the relevant operational situations are functional can only be given for the respective network operational situations tested. Such system integration operational tests are required due to the following issues: a) Specifications not fully validated; b) Test cases and test environment not fully validated; c) Certificates of the

subsystems with restrictions and conditions; d) Track-train system integration not fully validated; e) Different principles for CCS implementation caused by freedom of engineering applying the CCS specifications; f) Insufficient experience with harmonised transitions from one level to the other (e.g. ETCS L1 to L2)

The applicant for an APIS of a CCS SS has to prove integration of his subsystem within the railway system and for each network where it is intended to operate. To ease this process the technical development should allow transferring more tests into laboratories. However, execution of exhaustive on-site tests will be only a transitory situation. Having the growth of experience, stability and validation of the specifications and products, the amount of validation tests for system integration could be stepwise reduced to a minimum, as shown on Figure 3.

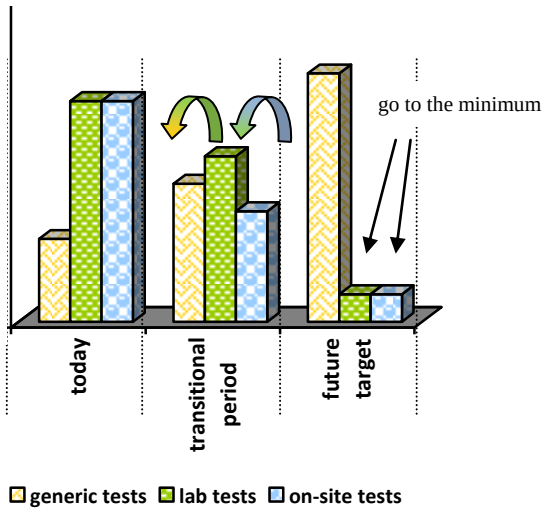

Fig. 3. Reduction of the CCS SS project specific lab and on-site testing

Some options are given here for the applicant to demonstrate that some tests have become no longer necessary.

- Validation test for system integration applied to an on-board SS CCS is proven to be fully covered by mandatory conformity tests (Subset-076);
- Lab tests can be taken into account if they have been performed in a way that ensures the same system behaviour on-site;
- CCS on-site tests can re-use the manufacturer's field tests during their CCS subsystem integration tests, if those cover the system integration operational test cases;
- Track-train system verification tests of a vehicle related to a specific route or network can be reduced by those tests successfully passed on other routes or networks if the conditions of the other routes or networks (engineering rules, operational scenarios) ensure the same system behaviour (equivalent test conditions).

The full scope of system integration tests will be tested only in the first projects within one network project. In the target situation, only conformity tests and a small set of final route or network specific tests will be necessary to re-authorise a vehicle or CCS SS for a network. Track-train system verification testing could finally be reduced to a few site tests for verification of TSI open points and some daily applied operational scenarios.

VI. Conclusion

In our days, the CCS SS testing framework call forth fuzzy and incomplete system integration and validation process. This is due to variety of subsystem definitions, certain degree of freedom for the required tests for APIS, not fully validated specifications, lack of national rules, etc. Deep analysis with interesting highlights of the legal framework, processes and participants within the APIS process is made in this paper to produce a proposal for improvement of the testing framework. The need for transitional period is discussed to consolidate the experience gained during the CCS SS testing with the purpose to reach a stable target situation in the next years.

Acknowledgement

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References

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[3] *Commission Decision of 25 January 2012 on the technical specification for interoperability relating to the control-command and signalling subsystems of the trans-European rail system (2012/88/EU)* and further amendments *(2012/696 and 2015/14).*

[4] European Railway Agency, *Guide for the application of the TSI for the Subsystems Control-Command and Signalling Track-side and On-board*, ver.2.0, 2013.

[5] *Commission Recommendation of 5 December 2014 on matters related to the placing in service and use of structural subsystems and vehicles under Directive 2008/57/EC and 2004/49/EC of the European Parliament and of the Council (2014/897/EU).*

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