

4.2.2 S2R-OC-IP1-02-2020: Technical solutions for the next generation of TCMS

SPECIFIC CHALLENGE

The Train Control and Monitoring System (TCMS) is the brain and the communications backbone of the train, which has some essential roles on vehicle performance. The next generation of TCMS should include wireless capabilities, should provide seamless coupling, enhanced interoperability, throughput and reliability, should be built on a new architecture based on distributed functions with standardised interfaces, while supporting safety-critical and security functionalities, and should offer easier certification procedures and self-configuration. S2R JU's CONNECTA-2 project (GA 826098) together with its complementary action SAFE4RAIL-2 (GA 826073) have been researching on new technologies to shape the next generation of train control and monitoring systems (TCMS). By the start of the present research and innovation activities, CONNECTA-2 is expected to have implemented and tested in laboratory demonstrators the following technologies:

- Drive-by-data concept (i.e. SIL4 capabilities for TCMS) including the integration of two safety related functions, Doors and Bogie Monitoring System (TRL 4).
- Functional distribution framework, through an integrated modular platform, including the integration of third party's HVAC function (TRL 4).
- Functional Open Coupling in the regional demonstrator, including remote hardware-in-the-loop environment (TRL 4).
- Completion of the virtual certification's simulation framework, its tools and the train virtualization, including remote hardware-in-the-loop. Application of the simulation framework in both demonstrators (TRL 4).
- Interoperability tests for the wireless Ethernet train backbone in the urban demonstrator (TRL 4).
- Tests for Wireless Consist Network in regional demonstrator (TRL 4).
- Implementation and validation of a number of uses cases for the new train-to-ground standard communication based on the IEC61375-2-6 (TRL 4).

This action aims to provide the technologies with the needed TRL for their validation in relevant environments.

SCOPE

In order to address the challenges described above, proposals should address all the following work streams, in line with the S2R MAAP:

This action aims at contributing to the demonstrators stemming from the topic S2R-CFM-IP1-02-2020, by supporting the S2R JU Members with the achievement of higher TRL (TRL 6/7). The contributions of this action are split in three main work-streams depending on the delivery deadline of the CFM demonstrators:

- Work-stream 1:
 - Antenna installation study to optimize transmission/reception in Wireless TCMS which includes the consist-to-consist transmissions, train-to-ground transmissions and internal consist wireless transmissions. Under the framework of complementarity, the action stemmed from this topic is expected to take as a reference the output in the field of the project S2R X2Rail-3⁴⁰.
- Work-stream 2:

⁴⁰ Expected to be delivered in November 2020.

- Subsystem functions adapted to Application Profiles⁴¹ with a TRL 6.
- Support for FDF integration in the FDF Hardware architecture.
- Conformance tests of the standard Application-FDF interface defined by CONNECTA-2 and the adaptation of DbD in the FDF (integrated in the FDF FW architecture).
- Deployment of a centralized configuration tool for Drive-by-Data (DbD) network equipment compliant to IEEE 802.1Qcc standard.
- Work-stream 3:
 - Independent Safety and Cyber security studies for DbD, FDF and Wireless TCMS.
 - Development of a methodology to develop SIL4 functions for the FDF and the tools to support a SIL4 application development provided by the complementary CFM.
 - Study on the integration of Time Sensitive Networking (TSN) transmission slots calculation (e.g. via a Centralized Network Configuration tool) and the FDF execution in order to achieve very low latencies.

In addition, this action shall provide the following equipment in order to support the action stemming from the topic S2R-CFM-IP1-02-2020 in the achievement of TRL6/7 demonstrators in deadlines fixed for work-stream 2:

- DbD network equipment: ETBN-TSN (Ethernet Train Backbone for Time Sensitive Networking), CS-TSN (Consist Switch for Time Sensitive Networking), NIC-TSN (Network Interface Controller for Time Sensitive Networking) final products products with a TRL 6/7⁴².
- FDF HW platform and development environment with a TRL 6/7⁴³.
- Time Sensitive Network Configuration Tool with a TRL 6/7.
- Wireless Train Backbone equipment⁴⁴, such as the Wireless Train Backbone Node and Antennas with a TRL 6/7⁴⁵.
- Wireless Consist Network equipment with a TRL 6/7.

In order to minimize the goal fulfilment risks of this action and its complementary CFM, the applicants to this action shall have industrial experience in the development of the demanded technologies, i.e. onboard train network equipment, railway safe HW platforms, IEEE TSN network equipment, WLTBN radio systems.

An indicative scheduling of the deliverables is suggested below⁴⁶ :

- Deliverable under work-stream 1 is expected by Q1 2022
- Deliverable under work-stream 2 is expected by Q3 2021
- Deliverable under work-stream 3 is expected by the end of the action

The S2R Joint Undertaking considers that proposals with a duration of 30 months would allow this topic to be addressed appropriately. Nevertheless this does not preclude submission and selection of proposals with another duration.

COMPLEMENTARITY

As specified in section 2.3.1 of AWP 2020 in order to facilitate the contribution to the achievement of the S2R JU objectives, the options regarding 'complementary grants' of the S2R JU Model Grant

⁴¹ Among the Application Profiles already defined by CONNECTA (Deliverable 4.3) and CONNECTA-2 (Deliverable D1.2) projects, available here: https://projects.shift2rail.org/s2r_ip.aspx?ip=1

⁴² A SIL2 certification is desirable.

⁴³ A SIL4 certification is desirable.

⁴⁴ Based on specification provided by CONNECTA-2 D1.1, Safe4Rail-2 D2.1 and D2.2, available here: https://projects.shift2rail.org/s2r_ip.aspx?ip=1 .

⁴⁵ A SIL2 certification is desirable.

⁴⁶ The scheduling of the deliverables is provided to facilitate the complementarity with the CFM actions and it is not binding. Additionally, each deliverable may have some flexibility in the scheduling

Agreement and the provisions therein, including with regard to additional access rights to background and results for the purposes of the complementary grant(s), will be enabled in the corresponding S2R JU Grant Agreements.

The action that is expected to be funded under this topic will be complementary to the actions that are expected to be funded under the following topics:

- S2R-CFM-IP1-02-2020

This action shall closely work with the action stemming from the complementary Call for Members call, to ensure integration of projects' results into the S2R JU.

The action stemming from this topic will also be complementary to actions carried out within the following projects:

- X2RAIL-3 (826141)

EXPECTED IMPACT

Actions will support S2R-CFM-IP1-02-2020 to validate in a relevant environment (TRL 6/7) and for two representative railway applications (i.e. regional and urban), the following technologies:

- The Drive-by-Data concept, including the elimination of train lines, obtaining a LCC reduction and operational reliability improvement.
- The Functional Distribution concept, together with the Integrated Modular Platform, leading to a reduction of LCC and improvement of operational reliability.
- The Virtual certification simulation framework to enable further reductions in LCC.
- The interoperability of the proposed Wireless Train Backbone and Wireless Consist Network, to reduce LCC, increase operational reliability and capacity, by adding flexibility to the system.

All in all, the relative weight of the benefits provided by this work on the overall system-level KPIs for the whole S2R JU initiative are estimated (over a total of 100%) as:

- Increase of capacity (potentially up to 20%).
- Increase of operational reliability (potentially up to 50%).
- Reduction of life-cycle costs (potentially up to 30%).

Type of Action: Innovation Action (IA)