S2R-OC-IPX-01-2018 - Paradigm shifts for railway

Specific Challenge:

Current activities in S2R are developing the fundamental building blocks that will allow in the future producing **interoperable and autonomous passenger or freight trains** that can run at a short distance from each other and have the ability to virtually couple and decouple as they travel on existing infrastructure.

Arising and **promising disruptive technologies** (e.g. A.I., robotics) will also contribute to shaping the way how future rail automation and maintenance will be organised and the subsequent strategic industrial developments on rolling stock and infrastructure.

The more advanced aspects of this approach and technologies can be developed in a potential continuation of the current S2R activities.

Once this technology is available, the **operational aspects** and the use of vehicles in general will change radically. It will be necessary to take a critical look at rolling stock and signalling/control-command and adapt them to the new needs, possibly creating many different concepts that may cover the wide range of needs that may arise, and also reviewing which new technology will need to be created and deployed.

New operational principles and industrial concepts that will be **digital and service oriented** ("railway 4.0") have the potential to radically transform the railway value and supply chain and ultimately benefit the final user, being the passenger or freight forwarder.

Even if these paradigm changes represent an apparently longer-term scenario for the railway sector, it is necessary to evaluate to the needs and feasibility of technologies/operations projected to play a major role is this potential future.

Scope**:**

The study (up to TRL 2) should formulate technological concepts tackling all of the following work-streams and their interconnection:

a) **Concepts for the future autonomous railway vehicles "train-centric"**

Here below some few possible technological points to look at (but not limited to) in the "train-centric" concepts (automatically running in existing railway infrastructure) the study should develop:

- Technology towards the "all electric" train (No pneumatics or hydraulics)
- Mechanical functions transferred to Electric / Electronics / Communications when possible (e.g. crash elements vs collision avoidance)
- State-of-art of technologies from other sectors to simplify and make manufacturing cheaper
- On-Board signalling intelligence moving to on-board the Interlocking and the Train Separation functions. Signalling system becomes Train-Centric based
- New structure and algorithms in order to achieve the train self-driving

The pre-identified aspects above should also be investigated in collaboration with the S2R-CFM-IP1-02-2018 and S2R-CFM-IP2-01-2018 and other relevant projects stemming from the CFM topics calls (in particular IP1 and IP2).

***b)* Promising disruptive technologies impacting automation systems and maintenance concepts**

Here below some possible technological points to look at (but not limited to) in the formulation of concepts making use of arising disruptive technologies :

- A.I. could become an "add on" for existing and future management systems providing suggestion/action for real time problem solving in order to comply with the basic safety and performance requirements, as well as it can guide the design process (e.g. data preparation and configuration).
- The new technologies today applied in robotics could be used for performing repetitive actions in checking infrastructure status and repairing/replacing devices. Also different and new concepts usage of robotics in the entire railway field could be part of this investigation (up to TRL2).

The pre-identified aspects above should also be investigated in collaboration with the S2R-CFM-IP2-01-2018 and other relevant projects stemming from the CFM topics calls (in particular IP2 and IP3).

c) Railway 4.0

Full system and life-cycle analysis on concepts as mobility as a service (MaaS), industry 4.0 (automated industry and industry as a service), railway clouds and decentralised ownership are among the ones this exploratory research should look at, providing a picture of the Railway 4.0.

In addition to considering the two previous work streams (but not limited to), here below some possible technological points to look at in the overall "Railway 4.0" concept:

- Machine to machine communication for Maintenance, Production, e.g.:
  - Axle counter knows it will soon have a failure,
  - Axle counter directly sends this diagnostic data to the supplier factory
  - Supplier factory builds spare part and delivers just in time
  - Digital supply-chains concepts and solutions

- Cloud centralised or decentralised services shared between transport companies for flexibility/scalability as well as service resiliency/availability, e.g.:
  - Investigation on future architecture that would leverage a service centric and self-organizing approach to minimize operational overhead and maintenance efforts.
  - Building blocks, which include but are not limited to software-defined networks, network function virtualization while embracing fog computing and edge computing for real-time critical applications.
  - Passenger and freight information systems integrated in a traffic and operation management of the railway system that is interconnected with other transport modes
  - Set up of a full railway IT ecosystem and connected business models that would ensure interoperability using advanced semantic technology independent from a unique standard for the entire railway value chain.

- Asset digitization, using IoT and big and open data processing and usage for the entire railway value chain

The aspects above and any more operational principle/industrial concept (up to TRL2) should also be investigated in collaboration with the other relevant projects stemming from the CFM topics calls (in all IPs).

Approaches to be incorporated in the proposal methodology:

- Comprehensive review of previous blue-skies EU/national funded projects related to this topic that did not find a way to the track/market, and critical evaluation of future applicability
- Trends in automotive, air and waterborne industry and analysis of transferability to railway rolling stock
- Forecast of evolution of key fundamental technologies, identification of technical risks and of potential blocking points
- Identification of key aspects for business feasibility
- Analysis of the current safety requirements and how the introduction of “train-centric” automated concept, the introduction of disruptive technologies and the digitalisation affect and change the railway safety approach
- Analysis of how the results the S2R running projects, planned from this AWP and in the MAAP directly contribute in the different work streams and concepts identified, and clarification of the missing components for their achievement

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-IP1-02-2018: Implementing new technologies for the TCMS
- S2R-CFM-IP2-01-2018: Advanced Signalling, Automation and Communication System
- S2R-CFM-IP3-01-2018: Research into optimised and future railway infrastructure

This do not preclude further necessary complementarity with other S2R projects related to other IPs.

As specified in section 2.3.1 of S2R AWP for 2018, in order to facilitate the contribution to the achievement of S2R objectives, the options regarding 'complementary grants' of the S2R Model Grant 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 Grant Agreements.

The S2R JU expect proposals of requesting up to 1.15M and plan to finance at least up to two projects.

Expected Impact:

The initial concept investigations should look forward the possible achievement of the following future impacts:

- Increased capacity
- Reduced LCC