ANNEX to GB decision no 8/2019

ANNUAL WORK PLAN and BUDGET 2020
adopted by the S2R GB on 14 November 2019

In accordance with the Statutes of the S2R JU annexed to Council Regulation (EU) No 642/2014 and with Article 31 of the S2R JU Financial Rules adopted by the Gouverning Board's Decision n° 21/2015.

The Annual Work Plan is made publicly available after its adoption by the Governing Board.

NOTICE

Please note that until the UK leaves the EU, EU law continues to apply to and within the UK, when it comes to rights and obligations; this includes the eligibility of UK legal entities to fully participate and receive funding in Horizon 2020 actions such as those called for in this work programme. Please be aware however that the eligibility criteria must be complied with for the entire duration of the grant. If the UK withdraws from the EU during the grant period without concluding an agreement with the EU ensuring in particular that British applicants continue to be eligible, they will no longer be eligible to receive EU funding and their participation may be terminated on the basis of Article 50 of the grant agreement.

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LIST OF ACRONYMS

Abbreviation	
AAR	Annual Activity Report
ABAC	Accrual Based Accounting
AI	Artificial Intelligence
ATO	Automatic Train Operation
ATP	Automatic Train Protection
A&V	Auralisation and Visualisation
AWP	Annual Work Plan
BEMU	Battery Electric Multiple Unit
BIM	Building Information Modelling
CA	Commitment Appropriation
CAPEX	Capital Expenditure
CBA	Cost Benefit Analysis
CBM	Condition-Based Maintenance
CCA	Cross Cutting Activities
CDM	Conceptual Data Model
CEI	Call for Expression of Interest
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CERT	Computer Emergency Response Team
CFM	Call for Members
(C)COLA	(Common) Collaboration Agreement
CSIRT	Computer Security Incident Response Team
CSA	Coordination and support action
D&E-Net	Dissemination and Exploitation Network
DMI	Driver Machine Interface
DOI	Digital Object Identifier
DRIMS	Dynamic Railway Information Management System
DSS	Decision Support System
EC	European Commission
ED	Executive Director
EN	European Norm
ERA	European Union Agency for Railways (formerly European Railway Agency)
ERRAC	European Rail Research Advisory Council
ERTMS	European Rail Traffic Management System
ETCS	European Train Controlling System
EU	European Union
FACTs	Flexible AC Transmission Systems
FFFIS	Form Fit Functional Interface Specifications
FIS	Functional Interface Specifications
FWC	Framework Contract

Abbreviation	
GA	Grant Agreement
GB	Governing Board
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GoA	Grade of Automation
H2020	Horizon 2020, EU Framework Programme for Research and Innovation
HMU	Hydrogen Multiple Unit
HST	High Speed Train
HVAC	Heating, Ventilation and Air-Conditioning
IA	Innovation Action
IAMS	Intelligent Asset Management System
IC	Innovation Capabilities
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
IKAA	in-kind contributions to additional activities
IM	Infrastructure Manager
IMU	Inertial Measurement Unit
IP	Innovation Programme
IPR	Intellectual Property Rights
ISO	International Standardisation Organisation
IT	Information Technology
ITD	Integrated Technology Demonstrator
JTI	Joint Technology Initiative
JU	Joint Undertaking
KPI	Key Performance Indicator
LCC	Life-Cycle Cost
LIDAR	Light Detection and Ranging
LTE	Long-Term Evolution (standard for wireless communication)
MAAP	Multi-annual Action Plan
MaaS	Mobility as a Service
MB	Moving block
MFF	Multiannual Financial Framework
MoU	Memorandum of Understanding
N&V	Noise and Vibration
NLOS	non-line-of-sight
NTP	Network Time Protocol
OC	Open Call
OCORA	Open CCS On-board Reference Architecture
ODM	Operational Data Management
OPEX	Operating Expenditure
OTM	On Track Machine
PA	Payment Appropriation
PTO	Public Transport Operator
RAIM	Receiver Autonomous Integrity Monitoring

Abbreviation	
RCA	Reference Command Control and Signalling Architecture
R-CSIRT	Railway Computer Security Incident Response Team
R&I	Research and Innovation
RU	Railway Undertaking
PPP	Public-Private Partnership
PRM	Persons with Reduced Mobility
PTC	Positive Train Control
PTI	Platform Train Interface
PTO	Public Transport Operator
RAL	Unpaid amount
RAMS	Reliability and Maintainability System
RBC	Radio Block Centre
RFID	Radio Frequency Identification
R&D	Research and Development
R&I	Research and Innovation
RIA	Research and Innovation Action
RoI	Return of Investment
S2R	Shift2Rail
SaaS	Software as a Service
SC	Scientific Committee
SERA	Single European Railway Area
S&C	Switches and Crossings
SiC	Silicon Carbide
SIL	Software in the Loop
SIWG	System Implementation Working Group
SME	Small and Medium Enterprise
SNE	Seconded National Expert
SPD	System Platform Demonstration
SRG	States Representatives Group
SWL	Single Wagon Load
SteCo	Steering Committee
TAF	Telematic Application for Freight
TAP	Telematic Application for Passengers
TCMS	Train Control and Monitoring System
TC	Tender Call
TD	Technology Demonstrator
TL	Train Load
TMS	Traffic Management System
TRA	Transport Research Arena
TRL	Technology Readiness Level
TSI	Technical Specifications for Interoperability
TSN	Time Sensitive Networking
TSP	Travel Service Providers
UAV	Unmanned Aerial Vehicle

Abbreviation	
URID	User Requirements Working Group
V&V	Verification & Validation
WA	Work Area

1. INTRODUCTION

The Annual Work Plan and Budget 2020 (AWP 2020) of the Shift2Rail Joint Undertaking (S2R JU) outlines the scope of the Research and Innovation (R&I) activities that will be performed as from 2020, implemented through call(s) for proposals and/or call(s) for tenders open to its Members, other than the Union, and third parties. It also details the governance structure of S2R JU and the underpinning 2020 Budget. It includes also the ongoing work in view of the preparation of rail research and innovation activities post-2020, under the new Multi-Annual Financial Framework (MFF) Programme 2021 – 2027.

It is another key step towards the digitalization and automation of railway systems, to achieve sustainable (decarbonised, life-cycle cost efficient, connected, integrated through a system approach) mobility for passengers and freight business.

The AWP 2020 shall be read in conjunction with the previous AWPs, Annual Activity Reports (AARs) and the work planned in the new S2R JU Multi-Annual Action Plan, which consists of three parts: MAAP Part A – Executive View (adopted by the S2R JU Governing Board on 27 October 2017[1]) and the MAAP Part B (adopted by the S2R Governing Board on 14 November 2019[2]). The original MAAP adopted by the Governing Board in 2015 Remains a reference point for some aspects related to the commitment of the Members other than the Union on assets availabilities for demos or similar.

In the introduction (Section 1), S2R JU's background, mission and objectives are described. Section 2 outlines the activities planned for 2020 including the support to operations, the S2R JU governance and internal control framework. Section 3 explains the S2R JU 2020 Budget.

NB: The present document is based on the template provided by the Commission Services, with some adaptations to introduce the specific needs of the S2R JU and to provide an encompassing view to its Governing Board.

1.1 The Shift2Rail Joint Undertaking

The S2R JU was established by Council Regulation (EU) No 642/2014 of 16 June 2014 (S2R Regulation) with, in Annex I, the S2R JU Statutes.

The S2R JU is a public-private partnership in the rail sector established under Article 187 of the Treaty on the Functioning of the European Union, providing a platform for the rail sector as a whole to work together with a view to driving innovation in the years to come.

The primary task of the S2R JU is to establish the priority research and innovation activities to accelerate the penetration of integrated, interoperable, and standardised technological innovations to support the Single European Railway Area (SERA) and to achieve operational excellence of the railway system. The European Railway Research Advisory Council (ERRAC) and the European Union Agency for Railways (ERA) consultations contribute to this process. Research activities with impact on ERA activities e.g. the technical specifications for Interoperability (TSIs), vehicle authorisations, safety certification, are always performed in close cooperation with ERA.

In addition, the S2R JU shall manage all rail-focused R&I actions co-funded by the Union, including outside the resources it has directly received.

1 Decision N° 6/2017 of 27 October 2017

2 Decision N° 9/2019 of 14 November 2019

Rail Research & Innovation (R&I) conducted within the S2R JU must contribute to address the challenges faced by the rail sector, through a comprehensive and coordinated approach to research and innovation focusing on the needs of the rail system and of its users, including in Member States that do not currently have a railway system within their territory.

In addition to the Union, which is a Founding Member, the S2R JU has eight other Founding Members[3] and nineteen Associated Members[4] ('hereinafter jointly referred to as members other than the Union'). The latter were selected following a call for expression of interest to become associated member of the S2R JU[5]

1.2 Mission and Objectives

The S2R JU is a mission-oriented Programme delivering a major system transformation, bringing railway at the centre of advanced integrated mobility.

The Vision of S2R JU is

To deliver, thorugh railway research and innovation, the capabilities to bring about the most sustainable, cost-efficient, high-performing, time driven, digital and competitive customer-centred transport mode for Europe.

Its mission statement is

"*Shift2Rail: moving European railway forward*".

In this respect, its main objective is to implement the S2R JU Programme and R&I activities in the railway sector in Europe, through the collaboration between stakeholders of the entire railway value chain, also outside the traditional rail sector, with particular attention to small and medium-sized enterprises (SMEs), research and technology centres and universities.

The rail R&I activities to be performed within the S2R JU are defined in the S2R JU Regulation and Statutes, translated in the strategic S2R Master Plan[6] and further detailed in the new S2R JU Multi-Annual Action Plan and its evolutions. Overall, the S2R JU shall:

- establish, develop and ensure the effective and efficient implementation of the S2R Master Plan, as referred to in Article 1(4) of the S2R Statutes;
- contribute to the implementation of Horizon 2020 Regulation and in particular part of the Smart, Green and Integrated Transport Challenge under the Societal Challenges pillar of Decision No 2013/743/EU;
- contribute to the achievement of the Single European Railway Area, to a faster and less costly transition to a more attractive, user-friendly (including for persons with reduced mobility), competitive, efficient and sustainable European rail system, and to the development of a strong and globally competitive European rail industry;
- play a major role in rail-related research and innovation, ensuring coordination among projects within its overall Programme. It provides all stakeholders with relevant and available

[3] Consisting of rail equipment manufacturers Alstom Transport, Hitachi Rail STS, Bombardier Transportation, Construcciones y Auxiliar de Ferrocarriles (CAF), Siemens AG, Thales and infrastructure managers Trafikverket and Network Rail

[4] AERFITEC consortium, Amadeus IT Group SA, AZD Praha s.r.o., CFW consortium, Deutsche Bahn AG, DIGINEXT, EUROC consortium, Faiveley Transport, HaCon Ingenieurgesellschaft mbH, Indra Sistemas S.A., Kontron, Knorr-Bremse GmbH, MER MEC S.p.A., Patentes Talgo S.L., Railenium Swi'TRACK'EN consortium, Smart DeMain consortium, SmartRaCon consortium, SNCF, Virtual Vehicle Austria consortium+

[5] Commission Decision C(2014) 7084 final

[6] http://ec.europa.eu/transport/modes/rail/doc/2015-03-31-decisionn4-2015-adoption-s2r-masterplan.pdf

information on R&I activities funded across Europe. It shall also manage all rail-focused research and innovation actions co-funded by the Union;
- actively promote the participation and close involvement of all relevant stakeholders from the full rail value chain and from outside the traditional rail industry. In particular, it fosters the involvement of small and medium sized enterprises (SMEs), as defined in Commission Recommendation 2003/361/EC (8);
- develop demonstration projects in interested Member States including those that do not currently have a railway system established within their territory.

The S2R JU shall, more specifically, seek to develop, integrate, demonstrate, and validate innovative technologies and solutions that uphold the strictest safety and security standards, the value of which can be measured against, *inter alia*, the following key performance indicators:

- a 50 % reduction of the life-cycle cost of the railway transport system, through a reduction of the costs of developing, maintaining, operating and renewing infrastructure and rolling stock, as well as through increased energy efficiency;
- a 100 % increase in the capacity of the railway transport system, to meet increased demand for passenger and freight railway services;
- a 50 % increase in the reliability and punctuality of rail services (measured as a 50 % decrease in unreliability and late arrivals);
- the removal of remaining technical obstacles holding back the rail sector in terms of interoperability, product implementation and efficiency, in particular by endeavouring to close points which remain open in Technical Specifications for Interoperability (TSIs) due to lack of technological solutions and by ensuring that all relevant systems and solutions developed by the S2R JU are fully interoperable and fitted, where appropriate, for upgrading;
- the reduction of negative externalities linked to railway transport, in particular noise, vibrations, emissions and other environmental impacts.

R&I activities are performed by members other than the Union and any other eligible entity co-funded by the S2R JU in accordance with its budget availabilities and in compliance with the Horizon 2020 Regulation[7] and its Rules of Participation[8]. To this end, the S2R JU shall organise calls for proposals for supporting the R&I activities and/or call for tenders, as needed.

As specified in Article 17 of the S2R JU Statutes, up to 70% of the total Union financial contribution to the S2R JU overall budget may be allocated to the R&I activities performed by the S2R JU's members other than the Union and their affiliated entities following competitive and transparent calls for proposals open to them. A minimum of 30% of the total Union financial contribution to the S2R JU overall budget must be implemented through open, competitive calls for proposals or calls for tenders (S2R JU members other than the Union are not eligible).

1.3 R&I priorities

The S2R Master Plan identifies the key strategic priorities, looking at a 2030 horizon, therefore encompassing R&I activities beyond the programmatic period of S2R JU. It proposes a holistic approach of the rail system that takes into consideration the relevant railway subsystems and actors, as well as their complex interaction (system demonstrators).

On 27 October 2017, the S2R JU Governing Board (GB) adopted an amended MAAP with a new Part A – Executive View which has replaced Part 1 and 2 of the original version of the MAAP adopted by the S2R JU Governing Board with Decision No 15/2015 of 27 November 2015. The MAAP Part A provides

[7] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:347:0104:0173:EN:PDF

[8] http://ec.europa.eu/research/participants/data/ref/h2020/legal_basis/rules_participation/h2020-rules-participation_en.pdf

an executive view, clarifying the S2R JU vision and its contribution to delivering European Union societal goals and identifying the associated set of twelve new capabilities that S2R JU will help develop and bring to the market. It describes the S2R JU Programme as a whole, summarising its purpose, structure, methodology and content and focuses on the series of intermediate steps through which it will bring about a radically improved railway system (urban/suburban, regional and high-speed passenger rail, freight), shaping the future mobility of people and goods. These steps will be taken through the development and implementation of the R&I activities planned in the MAAP, while capturing new technologies and following a European-wide System-of-Systems approach that is novel for the rail sector.

It explains how the MAAP and its detailed activities (as set out in the MAAP - Part B), within the framework of the original S2R Master Plan, are designed to deliver the vision of a radically improved railway system. It also explains the opportunities that this could bring to the railway industry and to society as a whole.

The Innovation Capability delivery strategy and associated implementation plan requires full cooperation between all stakeholders to prioritise and align efforts and resources.

As already mentioned, the new MAAP Part B re-focuses and prioritizes research and innovation activities in line with the MAAP Part A[9]. The MAAP Part B details which innovative solutions resulting from Technology Demonstrators (TDs) deliver the Innovation Capabilities (ICs). The TDs are organized in the following Innovation Programmes (IPs):

1.3.1 Innovation Programme 1 (IP1): Cost-efficient and reliable trains

The design of rolling stock plays a key role for the attractiveness of rail transport. Only trains that are comfortable, reliable, affordable and accessible can convince passengers to use rail transport instead of other modes. At the same time, the train design has to meet the requirements of the railway undertakings and the urban operators, who are the main customers of the rail supply industry, in order to deliver high quality and cost-efficient services to their customers.

If rail is to integrate more effectively with other modes and attract more passengers to further develop its role as the backbone of multi-modal mobility in the future, it needs a future generation of passenger trains that will be lighter, automated, more energy and cost-efficient, while at the same time providing a comfortable, connected, reliable and affordable travel experience for all passengers at a defined level of safety and security.

The S2R JU identified the following priority research and innovation areas in which activities should be undertaken with a view to achieving the ambition of IP1:

- Traction
- Train Control and Monitoring System
- Carbodyshell
- Running Gear
- Brakes
- Doors and Intelligent access systems
- Train interiors
- Heating, Ventilation and Air-Conditioning (HVAC)

Important areas of attention are those concerning noise and human factors (covered by CCA, and this IP has a significant contribution to make) and the link with the CCS system, in cooperation with IP2.

[9] On 20 May 2019 a revised draft of the simplified technical part of the MAAP was published, which constitutes Part B.

Compared to the investigation areas defined at the inception of S2R, in the review process of IP1, a new area of work is included to research on how to address new legislation related to HVAC.

1.3.2 Innovation Programme 2 (IP2): Advanced traffic management and control systems

Control, command and communication systems should go beyond being only a contributor to the control and safe separation of trains, and become a flexible, real-time, intelligent, integrated and fully automated traffic management system.

Although European Rail Traffic Management System (ERTMS) has already become a worldwide dominant solution for railway signalling and control systems, it has the potential to offer increased functionalities and become even more competitive.

Current systems do not sufficiently take advantage of new technologies and practices, including use of satellite positioning technologies, high-speed, high-capacity data and voice communications systems (Wi-Fi, 4G/Long Term Evolution (LTE) and their future generations), automation, as well as innovative real-time data collection, processing and communication systems, which have the potential to move towards new traffic management concepts (including predictive and adaptive operational control of train movements), thereby delivering improved capacity, decreasing traction energy consumption and carbon emissions, reducing operational costs, enhancing safety and security, and providing better customer information.

The S2R Master Plan identifies seven priority research and innovation areas in which activities should be undertaken with a view to achieving the ambition of IP2:

- Smart, fail-safe communications and positioning systems
- Traffic Management Evolution
- Automation
- Moving block (MB) and train integrity
- Smart procurement and testing
- Virtual coupling
- Cyber security

Important areas of attention are those concerning human factors (covered by CCA, and this IP has a significant contribution to make) and the link with shared train equipment, in cooperation with IP1.

In July 2018, the infrastructure managers (IM) and railway undertakings (RU) members of the S2R JU brought up a series of concerns about the progress of IP2 as well as some focus areas to deliver the key system transformation that is expected from the S2R Programme in the years to come. In particular, they brought forward the idea of a “reference command, control and signalling architecture” (RCA) that would contribute to a system integrated approach towards IP2 innovative solutions.

This work was discussed in different meetings within IP2 and it was agreed to assess the impact of the RCA on the S2R Programme (IP2 mainly, but also IP1 and IP5). The initial content of RCA was published in February 2019 (alpha version) and an update provided end of August 2019 (beta version). Where needed, it will allow the planning of IP2 in a manner to bring the in depth discussion within the S2R JU community[10] and in general the EU stakeholders, so that R&I requirements will meet technology

[10] All Members of the S2R JU (Founding and Associated Members) involved in IP2 for CCS and other IPs when relevant.

solutions to deliver the next generation of railway systems in line with the EU strategic vision and framework.

1.3.3 Innovation Programme 3 (IP3): Cost Efficient and Reliable High Capacity Infrastructure

The design, construction, operation and maintenance of rail network infrastructure have to be safe, reliable, supportive of customer needs, cost-effective and sustainable. In order to deliver the benefits of market opening and interoperability and to reduce the life-cycle costs of rolling stock and on-board signalling systems, the network diversity needs to be eliminated, notably through a migration towards common high-performing infrastructure system architecture.

Activities that can support the reduction of infrastructure maintenance costs, such as simplified procedures or automation, need to be led in priority. They should propose solutions that can be rapidly and efficiently deployed. Furthermore, the infrastructures have to be managed in a more holistic and intelligent way, using lean operational practices and smart technologies that can ultimately contribute to improving the reliability and responsiveness of customer service, as well as the capacity and the whole economics of rail transportation.

Compatibility between different elements of cross-modal transport infrastructure (such as multimodal hubs charging points and stations) needs to be ensured and based on principles of interoperability and standardisation.

The S2R Master Plan identifies six priority areas in which activities should be undertaken with a view to achieving the ambition of IP3:

- New directions in switches and crossings
- Innovative track design and materials
- Cost effective Tunnel & Bridge solutions
- Intelligent system maintenance
- Energy efficiency
- Improved station concepts

Important areas of attention are those concerning human factors (covered by CCA, and this IP has a significant contribution to make).

1.3.4 Innovation Programme 4 (IP4): IT Solutions for attractive railway services

In order to become more attractive, rail must respond to customer needs to support seamless door-to-door intermodal journeys encompassing different modes of transport. Rail must achieve interoperability with other transport modes and mobility services, within different regions, cities and across borders. In order to achieve this, rail needs to take due advantage of the ever growing connectivity of people and objects, the availability of European Global Navigation Satellite System (GNSS) based location and other means of localisation, the advances in cloud computing, Open Data and Big Data Analytics and the wide dissemination of Internet and social media. The step towards sharing data (as valid requirement for all IPs) needs to be considered and progressively developed, using open standards and specifications (including TAP TSI), in order to enable service developers to provide connected travellers with the services they need and expect. To achieve a full seamless multimodal travel experience, the customers must be able to easily plan, book and purchase door-to-door journeys. Ticketless or multi-application solutions that guarantee interconnectivity no matter

where the traveller journey should become the norm. The development of truly multimodal infrastructure, providing for simple and seamless interchanges, including among different transport modes (urban and regional rail, public transport including demand transport, air transport, road transport, cycling and walking, “shared services” - car sharing, bike sharing etc.), should make transfers easy, comfortable and reliable. For this reason, the services (not the single data) like timetables should be increasingly integrated across transport modes to allow better modal integration and minimise travellers' inconvenience.

The S2R Master Plan identifies three priority research and innovation areas in which activities should be undertaken with a view to achieving the ambition of IP4:

- Technical framework
- Customer experience applications
- Multimodal travel services

IP4 has been suffering some delays due to the unclarity of the membership status of one of its key partners. The situation has been solved and, taking into consideration the action plan submitted by IP4 Projects, it can be considered that the short delay will be reabsorbed in the year to come. Multimodal integration will also take benefit from exisiting rail standards as FSM and TAP TSI.

1.3.5 Innovation Programme 5 (IP5): Technologies for sustainable and attractive European rail freight

The cost competitiveness and the reliability of freight services need to be considerably improved if the rail sector is to meet the ambitious objectives that were set in the Transport White Paper[11] in terms of developing rail freight; almost doubling the use of rail freight compared to 2005, achieving a shift of 30% of road freight over 300 km to modes such as rail or waterborne transport by 2030, and more than 50% by 2050. Rail freight must be in a position to offer a cost-effective, attractive service to shippers, helping to take freight away from the already-congested road network, and becoming the backbone of the Union inland integrated logistic system.

Different market segments with specific technical and operational characteristics and needs have to be identified in order to direct research and innovation projects towards present and future market needs. The first segment is the intermodal segment, which mainly relies on the use of containers/trailer trains and where continued growth can be expected. Reliability, service characteristics and cost competitiveness in this segment can progress significantly with an increase in train length, better length utilisation, innovative rolling stock features for value-added services, progress in the terminal operations, improved real-time customer information to customers and better data exchange between involved parties in the intermodal transport chain using open standards and specifications (including TAF TSI). A second market segment is the wagon load activity segment (either Single Wagon Load (SWL) or Train Load (TL) services), which relies on the use of specific freight wagon. The SWL services have significantly declined in the past years and its significant growth potential can only be fully exploited if a step change is made in terms of service quality and reliability. Solutions such as automated coupling and decoupling and tagging of all wagons with automatically readable Radio Frequency Identification (RFID) tags, provide a huge potential to speed up and reduce costs in train formation and to improve the overall performance of wagonload services. An IT framework with high added value needs to be created for all topics described in this section. The need of comodality/multimodality of freight mobility , i.e. the linkage to other freight modes, has to be ensured.

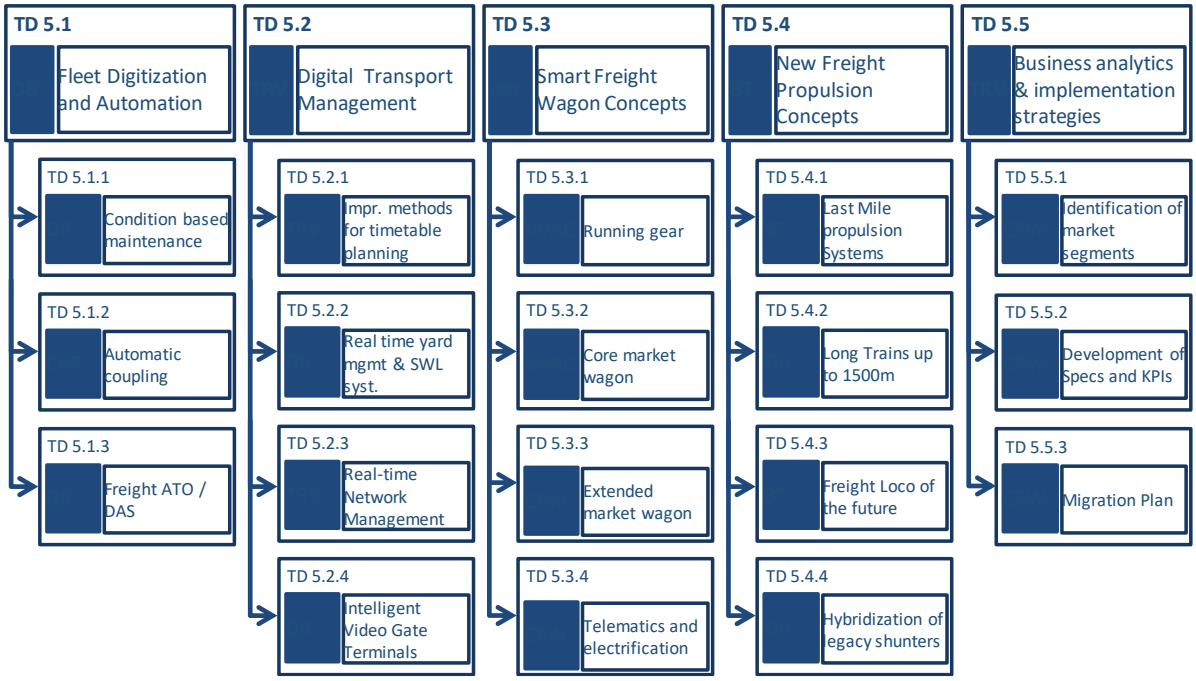
[11] WHITE PAPER Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system /* COM/2011/0144 final

The S2R Master Plan identifies eight priority research and innovation areas in which activities should be undertaken with a view to achieving the ambition of IP5:

- Implementation Strategies and Business Analytics
- Freight Electrification, Brake and Telematics
- Access and Operation
- Wagon design
- Novel Terminal, Hubs, Marshalling yards, Sidings
- New Freight Propulsion Concepts
- Sustainable rail transport of dangerous goods
- Long-term vision for an autonomous rail freight system

Important areas of attention are those concerning human factors (covered by CCA, and this IP has a significant contribution to make).

During the past years, IP5 has re-prioritized its TDs. IP5 includes the following TDs which are a reference point for the present AWP2020.



1.3.6 Cross-cutting themes and activities

In addition to the five Innovation Programmes, the work of R&I activities will include cross-cutting activities (CCA) relevant to each of the different sub-systems and taking into account the interactions between these sub-systems.

These CCA activities will ensure that the R&I activities within the different Innovation Programmes are closely aligned in terms of their objectives and their requirements, as well as the methodologies for evaluation and assessment of impacts. These activities include elements already taken into account in the different Innovation Programmes that require horizontal coordination (such as energy and noise management) and additional R&I that will be necessary to complement the technical work of the S2R JU.

The S2R Master Plan identifies five priority research and innovation areas in which activities should be undertaken with a view to achieving the objectives of the CCA:

- Long-term needs and socio-economic research
- Smart materials and processes
- System integration, safety and interoperability
- Energy and sustainability
- Human capital

Beyond the technical challenges addressed by IPs and CCA, the market uptake of innovative solutions shall address barriers such as: product acceptance, development of specific business cases, development of appropriate charging mechanisms, development of appropriate standards for innovative products, etc.

In addition to the concept underpinning the S2R JU that contributes to eliminating the aforementioned barriers, the new solutions will be supported by cost-benefit analyses (CBA). The overall S2R JU activities will embed, when applicable, suitable work to prepare for future technical standardisation/regulation related to the proposed innovations.

1.3.7 IPx - System Architecture and Conceptual Data Model (CDM)

As indicated in the section dedicated to IP2, since 2018 work started at the initiative of some Infrastructure Managers on the Reference Command Control Signalling Architecture (RCA) and recently by some Railway Undertakings with an Open CCS On-board Reference Architecture (OCORA). In addition, the S2R JU during 2019 launched its activities related to the development of a Conceptual Data Model that will contribute to overcome “data” and “systems” fragmentation with a view to produce a system of systems approach; this will become the standardized way for legacy and new systems to interact, ensuring their interoperability.

With the award of the Linx4Rail Project in 2019, the S2R JU has now, formally, research and innovation activities dedicated to an encompassing Functional System Architecture that cover safety and non-safety aspects, bringing together the different railway subsystems with a modular approach, standard interface between key functional components while preserving know how and competitiveness. It will be a cornerstone of the R&I Programme, including after 2020, and it will contribute to achieve a major transformation with the creation of an integrated and connected railway system, introduce a structured approach to the functional evolution of the railway systems, integrating within the S2R JU the Members and actors currently not directly involved in the JU, relying on the progress achieved within different stakeholder groupings, or at company level, in view of providing the sector with a shared path and vision of the future operations of rail systems, under the policy leadership of the European Commission and in strict coordination and collaboration with ERA.

2. WORK PLAN AND BUDGET 2020

2.1 Executive Summary

In the "Political guidelines for the next European Commission 2019-2024", President Elect Ursula von der Leyen presented as number 1 priority "a European Green Deal". To make the Union "*the world's first climate-neutral continent is the greatest challenge and opportunity of our times. It involves taking decisive action now. We will need to invest in* ***innovation and research, redesign our economy and update our industrial policy***".

In this context, the S2R JU and its Programme should enhance their impact to meet the expectations of the European Citizens as framed in the President Elect priorities. In the same context, the S2R JU Programme will continue to assess its contribution to the Sustainable Development Goals of the United Nations and report on them.

In this respect, the MAAP - Part A provides an Executive View, clarifying the S2R JU vision and its contribution to delivering European Union societal goals and identifying the associated set of twelve new Innovation Capabilities that the S2R JU will help develop and bring to the market. It describes the S2R JU Programme as a whole, summarising its purpose, structure, methodology and content and focuses on the series of intermediate steps through which it will bring about a radically improved railway system (urban/suburban, regional and high-speed passenger rail, freight), shaping the future mobility of people and goods. These steps will be taken through the development and implementation of the R&I activities planned in the new MAAP Part-B, complemented by the commitments identified in the MAAP 2015 if needed, while capturing new technologies and following a European wide system of systems approach that is novel for the sector. Building upon the ongoing R&I work framed in the 2015 – 2019 Projects, the AWP 2020 brings, on the one hand, R&I activities to a higher TRL level towards demonstrators and possibly future ITDs (Integrated Technology Demonstrators) and, on the other hand, explores new areas and new technologies that will contribute to foster the system transformation of railway.

With this AWP 2020, which should bring to completion those research and innovation activities started in 2015 and expected to reach TRL7, 17 new projects are expected to be launched and they will consist of:

- either demonstration with prototypes of new technologies into operation or test facilities,
- or in supporting activities with lower Technology Readiness Level (TRL), based on new emerging concepts and coming from the digital world, basic science or elsewhere, to pave the way for future research and innovation.

This Call for Proposals will be complemented in an integrated manner by Calls for tenders to avail the S2R JU and its members other than the Union with additional expertise.

The S2R JU's AWP 2020 describes the R&I activities to be executed by its members other than the Union and beneficiaries of Open Calls (OCs) in the next years building upon the results coming from ongoing S2R JU projects.

The 2020 AWP includes the following operational activities:

- launch of calls for proposals, tenders and prizes for a total value of the action of EUR 151.5 million:
    - competitive call for proposals (IA) for S2R JU Members other than the Union with a total value of the actions of EUR 123.8 million (max S2R JU co-funding EUR 55.4 million);

    - open calls for proposals (RIA and IA), where the S2R JU Members other than the Union are excluded from participation, with a total value of the actions of EUR 22.8 million (max S2R co-funding EUR 20.0 million);
    - EUR 4.4 million to implement framework contracts awarded in the previous years;
- other activities include: monitoring and review of the R&I activities up to EUR 0.5 million.

The new research and innovation activities will be integrated in the overall Programme and its governance, in particular under the newly established ED Programme Board to ensure transparently the alignment of the different projects to the overarching objectives of the S2R JU.

In the domain of stakeholder management and external relations, stakeholders include European and national decision makers, S2R JU Members, other JU's, potential applicants for calls for proposals and new stakeholders, European and national funding bodies, and also forwarders, carriers and the transport as well as passenger traffic associations.

The year 2020 will see the continuation of the close collaboration established between the S2R JU and:

- the European Railway Research Advisory Council (ERRAC),
- the European Union Agency for Railways (ERA),
- different associations representing the key stakeholders of the rail sector and beyond, in different areas.

The ongoing work on collaboration agreements, in the form of a Memorandum of Understanding (MoU) or cooperation agreement, signed by the S2R JU with various European regions and Member States, European and international organizations and bodies will be pursued. In addition to the cooperation agreement signed with SEESARI on 18 September 2018, the MoU signed with the Czech Republic on 4 January 2019, the MoU signed with ETSI on 14 May 2019, other agreements are expected to be signed during 2019:

- European regions in Spain, and possibly other Member States,
- and a cooperation agreement with CUTRIC-CRITUC.

Further agreements or letters of intent could be foreseen in areas of interest for the programme, e.g. with standard setting organisations or sector organisations that facilitate the implementation of the rail related European legal framework (e.g. RNE, etc.).

Stakeholder management will also provide answers to some recommendations included in the S2R JU Interim Evaluation of 2017, in particular in view of the next Programming period. Stakeholder engagement will also continue being developed within the context of the EU's external Transport policy.

The S2R JU will continue participating in specific activities, workshops and events in order to advertise, communicate and disseminate the successful achievements of its Partnership. Building upon the achieved results, the S2R JU intends to show some of its achievements at events throughout 2020, such as the InnoTrans 2020 on 22-25 September in Berlin, the Transport Research Arena (TRA) 2020 (27-30 April) in Helsinki, and TEN-T Days 2020 in Sibenik, Croatia.

The possibility of organizing a S2R JU Innovation Day dedicated to the research community is also considered.

Together with the European Commission, the S2R JU will support the rotating Presidency of the Council on railway events organized in the different Member States. In the same manner, the S2R JU will interact with the European Parliament, in particular TRAN and ITRE Committees.

In addition, the S2R JU will:

- continue raising awareness about R&I in railway as an instrument for the industry's sustainability and competitiveness, growth and jobs;
- promote stakeholder engagement;
- promote the S2R JU within the EU Institutional arena;
- maintain a network of press and media contacts;
- pro-actively publish communication material;
- mobilise applicants for S2R JU open calls for proposals, with particular focus on SMEs and EU-13 Member States;
- manage the S2R JU website;
- continue leading a coherent dissemination strategy, including a standardisation and regulation roadmap, to foster market uptake.

At a corporate level, the S2R JU will ensure an accurate baseline for workloads, costings and staffing levels needed to ensure successful delivery of the Programme. As part of a continuous learning/improving approach, relevant processes within the S2R JU will be configured and managed effectively throughout 2020 to ensure continuity of service delivery.

The AWP 2020 aims to provide a detailed view of all activities to be undertaken and objectives to be achieved during 2020 to meet these goals, drawing from S2Rs MAAP and its evolution.

2020 will be also critical in all the discussions related to the next generation of the railway research and innovation programme, as part of the Horizon Europe proposal of the European Commission to the Member States and European Parliament. In the last three years, the S2R JU has demonstrated the progress achieved through the commitment of its Members and stakeholders. The system transformation to which the S2R JU is expected to substantially contribute does not end in 2020, or 2024, but it requires a major effort in the years to come, connecting fundamental research – applied research – large scale demonstrations/deployment. The system approach brought forward by an institutional partnership such as the S2R JU has proved to be capable of delivering such major transformation, involving legislator, regulator, standardisation bodies and stakeholders.

Finally, the S2R JU will take also direct actions to reduce the Carbon Footprint of its activies and a specific action plan will be put in place during 2020 and duly monitored.

2.2 Operations

2.2.1 Objectives & indicators

The overall objectives for the S2R JU programme in 2020 are the following:

- To progress in the R&I activities, taking into account the review of the MAAP made in 2017 and ongoing in 2019, with the objective of, as far as possible, prioritize and accelerate some activities; this will be achieved through the award of grants/contracts resulting from call(s) for proposals and/or call(s) for tenders;
- To ensure that the 2020 wave of calls for proposal and/or tenders takes due consideration of the relevant results achieved by the ongoing projects and that relevant mechanisms to address it are embedded in the specific agreements and or contracts. In addition, it should be duly focused on technology demonstrators' results;
- With regard to the latter, to ensure demonstration activities are duly prepared and performed also in view of the authorisation/certification processes for their testing in operational environments, together with ERA and national authorities;

- To ensure that the assessment of intermediary and/or final results and the respective payments are made within the set time limits for the relevant agreements and/or contracts;
- To follow up and provide due feedback on the implementation of the Lump Sum Pilot Grants, in line with the simplification measure introduced by the Commission, while providing for sound financial management;
- To contribute to the preparation of railway R&I beyond the present Programme, covering the full spectrum of R&I activities from Blue Sky and fundamental Research to demonstrations and management deployment;
- To monitor and ensure the continuous follow up of the actions agreed at the S2R JU Governing Board in response to the recommendations of the interim evaluations of the S2R JU;
- To support the Commission in its outreaching activities, including outside Europe, in accordance with the provisions of Article 2(k) of the S2R Statutes.

An indicative list of Key Performance Indicators (KPIs) has been elaborated by the Commission aiming at the establishment of three groups of indicators, namely:

- Horizon 2020 Key Performance Indicators[12] common to all JTI JUs;
- Indicators for monitoring Horizon 2020 Cross-Cutting Issues[13] common to all JTI JUs;
- Key Performance Indicators specific for S2R JU, as a result of the new model established by year end 2018 and attached to the AWP 2019. Release 2020 is attached to the present AWP.

They can be consulted in the Annex III to this document.

2.2.2 Risks & mitigations

The table below indicates the main risks associated with the Programme activities and the financial administration of the S2R JU, as well as the corresponding risk mitigation actions. Only risks requiring continuous Executive Director (ED) - and where relevant, S2R JU GB attention and treatment, due to their criticality, are reported.

A new risk assessment exercise has been performed mid-2019 and its results reflected in the present table.

Risk identified	Action Plan
	•
Interdependencies create delays or inadequacies in the completion of activities in grants that are complementary or prerequisites to grants to be awarded under following AWPs, generating a negative cascading effect.	Ensure, through adequate program management, strengthened monitoring and reporting of projects, including gate reviews to determine whether specific actions need to be taken with regard to a specific project (re-orientation, early closure, etc.). New ED Programme Board in place.
Cross-project collaboration required to achieve the programme objectives may not be achieved due to 'silo-project management' or restrictions related to 'licenses', 'patents', 'IPR Member's sharing policies' or 'accessibility of past OC project results'.	• New ED Programme Board in place • significant implication of the System Implementation Working Group (SIWG) • decoupling IP structure from AWP topics • further fostering the use of a common S2R JU Cooperation Tool and sharing functionalities

[12] Based on Annex II to Council Decision 2013/743/EU
[13] Based on Annex II to Council Decision 2013/743/EU

Risk identified	Action Plan
	• dedicated cross-IP meeting • IP coordinators meeting • models and guidance from the S2R JU • SIWG informal conflict resolutions • simplification of legal structure for collaboration. A S2R JU Common Collaboration Agreement (Common COLA, or 'CCOLA') is under preparation. • in order to ensure connection with national activities, the S2R JU will consider signing specific collaboration agreements with other European and international Organizations, Regions and Member States.
Delays in project execution or other impediments (e.g. staff-resource constraints) might lead to underspending of resources.	• Better monitoring of the consumption • Re-allocation of activities (Revision of activities in the Programme & MAAP) • Monitoring from conception phase of Grant Agreement (GA) until final payment (and multi-annual objective at programme level).
High staff turnover together with difficulties to attract new people (e.g. due to the general 'rivalry for talent') might result in positions being filled in with delays (increased risk during peak moments) and as a consequence leading to difficulties in getting the work done or achieving the JU's objectives; this may include a negative impact on other employees' motivation).	This risk is intrinsic to the S2R JU Staff establishment plan. Nevertheless, within the budget constraints, a career plan for staff has been prepared and business continuity is ensured. In 2018, the S2R JU GB adopted a revised decision on Learning and Development; implementing policy was adopted in April 2018 by the ED. Enhancing the planning of activities will allow for better risk management. Recruitment of short term resources (interim or trainees) should be aligned accordingly.
Significant cuts in the EU's budget might lead to a decrease in the S2R JU's budget which might result in insufficient (financial) resources to realise the objectives of the JU.	The S2R JU Membership shall put in place all the measures to provide all the elements to the budget authority to reduce such a risk. The S2R JU together with the members other than the Union are working actively in demonstrating that the S2R JU Programme is already providing results (TRA, Innotrans, Demo, etc.). Moreover, the available resources will be subject to proper planning and regular follow up with Members and at IPSteCo/SIWG level, Projects control gates level, and subject to regular reporting to the S2R JU GB.
In accordance with the Horizon 2020 Rules for Participations and considering the resources available on a yearly basis, the Programme shall be implemented through Projects financed by annual grants. Largely, this may result in a piecemeal approach instead of innovative solutions towards a new integrated, connected and automated railway system. This may result in questioning the sound financial management of the implementation process through grants,	Qualitative mitigating measures are identified and implemented to contain and monitor the identified risks. This is realised through the S2R JU GB, SIWG and IP SteCos which maintain a Programme view compared to a piecemeal project view. The S2R JU will keep on assessing the sound financial management risks and possible adequate measures implemented accordingly. Introduction of integrated demo plans, finalised in 2019

Risk identified	Action Plan
especially regarding Members already selected through open competition and commitment.	
Lack of adequate dissemination of results may result in suboptimal information reaching the end-user/interested parties, which could compromise the S2R JU JU's impact.	The S2R JU provided a series of guidelines to the projects and fostered the use of the Horizon 2020 instrument as the Common Dissemination Booster. Proper planning and regular follow up at IPSteCo/SIWG and projects' control gates' levels are ensured.
Characteristics of the project setup (e.g. the project execution team at a task/sub-task level belongs to one and the same private company without applying a broader scope) might result in a project outcome that represents a single company solution and is therefore non-interoperable on a broader spectrum, and is not in line with the philosophy of the S2R JU.	Demo planning, regular follow up at IPSteCo/SIWG and projects control gates' levels are ensured.
Difficulties in obtaining the necessary authorisation(s) to organise project demonstrations might provoke a significant delay resulting in the inability to organise these demonstrations or in their partial organization.	Planning anticipation (Demo planning) and regular follow up at IPSteCo/SIWG, ERA involvement and regular reporting to S2R JU GB are ensured.
Impediments during a project (e.g. changes in regulation/ non-achievement of harmonised requirements/unforeseen planning difficulties in resource planning etc.) might lead to the project not being executed in a timely and/or adequate manner, preventing S2R JU solutions from reaching the market.	Ensure the following actions: • appropriate implementation/exploitation plans in Grant Agreement and at TD/IP level • national migration strategies • investigate possible instrument to support deployment at EU level and implement the S2R JU strategy/support • regular follow up of the S2R JU standardisation roadmaps • coordination with RASCOP, and also directly with ERA, CEN/CENELEC/ETSI • Regular follow up at IPSteCo/SIWG • regular updated with URID WG • Monitoring of the regulatory environment
The migration and rollout of the developed technologies is not taken into account, but should be already considered at the design stage to reach high market acceptance in a short time-frame.	Project design should consider the identification of a proper business case to accelerate market acceptance, within the overall partnership of the S2R JU.
Risk that a lengthy process leading to a possible S2R2 Programme may negatively impact the ongoing R&I activities, with, on the one hand, Members looking at the future instead of investing on current R&I activities, and, on the other hand, de-commitment in case of negative decision	Transparent and timely involvement of the membership in the next MFF preparation

As regards the uncertainties related to Brexit negotiations, the S2R JU monitors the situation in accordance with the instructions issued by the competent Commission services.

2.2.3 Scientific priorities & challenges

The R&I priorities of the S2R JU Programme are described in section 1.3. This section introduces the priorities which will be important in 2020 and are reflected in the topics included in the 2020 calls for proposals and/or for tenders.

The S2R JU published its first calls for proposals on 17 December 2015 and since then and up to the AWP2019 whose implementation will start in Q4 2019, around EUR 305 million of funding are committed (+/- 36 months). Moving from initial lower TRLs, the activities are now engaged in all IPs and some TDs have started to work on the setting up of the demonstrations activities, enabling the timely completion of TDs and their further incorporation into Integrated Technology Demonstrators (ITDs).

In 2020, the S2R JU on the basis of the results of the ongoing and closed projects, including the Lighthouse Projects, will launch a call aiming, on the one hand, at reaching the next TRL, thus bringing the Programme closer to completion and, on the other hand, new exploratory research activities that will be looking beyond current approaches and may bring disruptive innovative solution through the implementation of new technologies, artificial intelligence, integrated digitalisation, etc.

The call encompasses topics for proposals to the five Innovation Programmes and the CCA. In this way, both an adequate coverage of the Programme activities and its rail value chain as well as the integration of new actors and components will be ensured.

2.2.4 Operational activities planned in 2020

Following an analysis conducted with the contribution of the IP SteCo's and the SIWG, and after having had a fist consultation with the Scientific Committee (SC), the States Representatives Group (SRG) and ERA, the AWP 2020 includes integrated topics to further enhance the synergies between IPs and CCA.

Overall, the following types of activities have been identified:

- projects progressing up to TRL 7 by 2022 which build on the work conducted in the Lighthouse Projects and the last S2R calls;
- projects achieving lower TRL by 2022, which embed some flexibility and may result in readjusted innovative solutions more adapted to the evolving medium-term needs;
- "blue sky" and fundamental research projects (mostly OC Projects) which may offer the opportunity to plant the seeds of the future R&I work beyond 2020, still in line with the time horizon considered in the Master Plan. This activity in exploratory research is essential to ensure that the railway system evolves to capture the mobility needs of the passengers and logistic aspects beyond addressing identified shortcomings;
- Innovation activities to establish the baseline upon which S2R JU Innovative solutions will be built, such as those needed to support the implementation of the European Deployment Plan related to ERTMS.

The table below identifies the topics related to the call that the S2R JU is planning to launch in 2020.

Activity	Type of call	Value of the actions (*)	Maximum S2R co-funding (*)	In-kind contribution (*)	Other contributions from non Members	Indicative publication date
Call for Proposals	JU members eligible only	123.8	55.4	68.4	0	Q1 2020
Call for Proposals	Open, JU Members excluded	22.8	20.0		2.8	Q1 2020
Call for Tenders	Open	4.4	4.4	0	0	n/a implementation of ongoing contracts
Prizes	Open	0.5	0.5	0	0	
Operational Experts	Open, including through REA and Call for expression of interest (CEI)	0.5	0.5	0	0	
Total		**152.0**	**80.8**	**68.4**	**2.8**	

(*) indicative figures in EUR million

2.2.5 Call for proposals and/or Call for tenders - S2R JU members eligible only

This section presents the list of topics that will be included in the call for proposals/call for tenders for S2R JU Members.

In 2020, the S2R JU is planning to issue a call for proposals and/or call for tenders addressed to S2R JU Members only. The budget for this call is estimated at EUR 55.4 million (in S2R co-funding). This amount will be the co-funding estimated to be paid by the S2R JU against R&I activities for EUR 123.8 million (the difference, EUR 68.4 million, corresponds to the indicative minimum value of the net in-kind contributions of the members other than the Union, which is subject to audit certification).

High-level initial topic descriptions are provided in the Annex I to this AWP 2020.

The topics that are included in the calls are broad in nature, but combine tasks which need to be developed in close cooperation and in the same initial timeframe for achieving the long-term objectives included in the S2R JU Programme.

It is foreseen that the call for proposals will be launched in Q1 2020, with activities expected to start towards year end 2020.

Proposals should be invited for the following topics:

Topic number - IP	Topic name	Type of action and expected TRL	Value of the actions (*)	Maximum S2R co-funding (*)	In-kind contributions from members other than the Union (*)
S2R-CFM-IP1-01-2020	Demonstrators for the next generation of traction systems, smart maintenance, virtual validation and eco-friendly HVAC, and Technical research on battery and hydrogen powered regional trains (BEMU/ HMU) (IP1/IP3)	IA up to TRL 7	19,989,892.01	8,971,000.00	11,018,892.01
S2R-CFM-IP1-02-2020	Validation of new technologies for the TCMS	IA up to TRL 7	8,755,765.73	3,983,000.00	4,772,765.73
S2R-CFM-IP2-01-2020	Completion of activities for Adaptable Communication, Moving	IA up to TRL 7	32,722,599.13	14,970,000.00	17,752,599.13

Topic number - IP	Topic name	Type of action and expected TRL	Value of the actions (*)	Maximum S2R co-funding (*)	In-kind contributions from members other than the Union (*)
	Block, Fail safe Train Localisation (including satellite), Zero on site Testing, Formal Methods and Cyber Security				
S2R-CFM-IP3-01-2020	Research into optimised and future railway infrastructure	IA up to TRL 7	26,463,665.58	11,408,000.00	15,055,665.58
S2R-CFM-IP4-01-2020	Enhancing IP4 Ecosystem	IA up to TRL 7	11,298,037.23	5,207,000.00	6,091,037.23
S2R-CFM-IP5-01-2020	Formulation of the freight train of the future	IA up to TRL 7	17,705,800.15	7,879,000.00	9,826,800.15
S2R-CFM-IPX-01-2020:	Advanced Functions towards Autonomous Trains	RIA Up to TRL 5	4,550,833.67	2,021,000.00	2,529,833.67
S2R-CFM-IPX and CCA-02-2020	Evolution of Railways System Architecture and Conceptual Data Model (CDM)	RIA TRL 3/4	2,344,303.16	1,041,000.00	1,303,303.16
TOTAL			123,830,8967	55,480,000	68,350,8967

(*) indicative figures in EUR

2.2.6 Open call for proposals for non-JU members

This section presents the indicative list of topics that will be included in the open call for proposals for non-S2R JU members, addressing the broader research and innovation community.

In 2020, the S2R JU is planning to issue one call for proposals addressed to non-S2R JU members. The budget for this call is estimated at EUR 20.0 million (in S2R co-funding). This amount will be the co-

funding estimated to be paid by the S2R JU against R&I activities for EUR 22.8 million (the difference, EUR 2.8 million, corresponds to the non-funded activities).

Detailed topic descriptions are provided in the Annex II to this AWP 2020.

It is foreseen that the call for proposals will be launched in Q1 2020, with activities expected to start towards year end 2020.

Proposals should be invited for the following topics:

Topic number - IP	Topic name	Type of action and expected TRL	Value of the actions (*)	Maximum S2R co-funding (*)	Other contributions from non Members (*)
S2R-OC-IP1-01-2020	Support to Development of next generation of Traction systems (TD1.1)	RIA TRL 3	2,300,000	2,300,000	0
S2R-OC-IP1-02-2020	Network and end-device equipment for the validation of the next generation of TCMS (TD1.2)	IA TRL 6/7	6,571,429	4,600,000	1,971,429
S2R-OC-IP1-03-2020	Innovative technologies for Carbodies and Running Gear of the future (TD1.3 + TD 1.4)	RIA TRL 5/6	2,420,000	2,420,000	0
S2R-OC-IP2-01-2020	Modelling of the Moving Block system specification and future architecture (TD2.3) + RAIM algorithms, Assessment Report and support for Railway Minimum Operational Performance Standards (TD2.4)	RIA up to TRL 3/4	1,340,000	1,340,000	0
S2R-OC-IP2-02-2020	Study on alternative bearers and on	RIA TRL 4/5	350,000	350,000	0

Topic number - IP	Topic name	Type of action and expected TRL	Value of the actions (*)	Maximum S2R co-funding (*)	Other contributions from non Members (*)
	communication protocols				
S2R-OC-IP3-01-2020	Next Generation Track Transition Zones (TD3.4)	RIA TRL 5/6	1,350,000	1,350,000	0
S2R-OC-IP3-02-2020	Technology Development for Railway Systems Asset Management (TD3.6)	RIA TRL 4/5	1,710,000	1,710,000	0
S2R-OC-IP3-03-2020	Advanced tools and equipment: collaborative robots & wearable mobile machines (TD3.8)	RIA TRL 5/6	2,700,000	2,700,000	0
S2R-OC-IP4-01-2020	Supporting the implementation of the IP4 multi-modal transport ecosystem (iTD4.7)	IA TRL 6/7	2,857,143	2,000,000	857,143
S2R-OC-CCA-01-2020	Noise and Vibration (WA5)	RIA TRL 3/4	950,000	950,000	0
S2R-OC-IPX-01-2020	Innovation in guided transport	CSA	250,000	250,000	0
TOTAL			**22,798,572**	**19,970,000**	**2,828,572**

(*) indicative figures in EUR

2.2.7 Call planning

The S2R JU plans to launch a call for proposals addressed to S2R JU Members other than the Union and an open call for proposals addressed to non-S2R JU Members. The key activities for the management of the foreseen 2020 calls for proposals are presented in the table below:

2020 Management process for the call for proposals addressed to S2R JU members other than the Union	Indicative timing
Preparation of the call for proposals	Q4 2019
Publication of the call for proposals	Q1 2020
Deadline for the submission of proposals	Q2 2020

Selection of the experts and evaluation of proposals	Q2 2020
Preparation and signature of S2R JU Model Grant Agreement for S2R JU members (*)	Q3 2020
2020 Management process for the open call for proposals addressed to non-S2R JU members	**Indicative timing**
Preparation of the call for proposals	Q4 2019
Publication of the call for proposals	Q1 2020
Deadline for the submission of proposals	Q2 2020
Selection of the experts and evaluation of proposals	Q2 2020
Preparation and signature of S2R JU Model Grant Agreement for non-S2R JU members (*)	Q3 2020

(*) Maximum Time to Grant of 8 months from the deadline for the submission of proposals.

A similar timetable will be applied in the case call for tenders and prizes will be implemented. The rules applicable to a call for tender and prizeswill be in compliance with the S2R JU Financial Rules and consequently Title VII of the Financial Regulation[14].

2.2.8 Call for tenders and prizes

2.2.8.1 Call for tenders

In 2020, the S2R JU is planning to issue or implement the following call for tenders within framework of the S2R MAAP.

The calls for tender (indicated in table '1-contract') is scheduled not later than Q3 2020; they will be subject to the provision of the S2R JU Financial Rules.

Number	Subject of tender	Indicative scope	Maximum budget*
1 – contract (implementation)	Support to ERTMS European Action Plan to pave the way for the deployment of the future S2R JU Innovative Solutions	Implementation of a 4-year framework contract with a total estimated value of EUR 8 million. The estimated respective share for 2020 amounts to EUR 2.0 million.	2,000,000 (specific contracts for 2020)
2 - contract (implementation)	Strategic support to the S2R JU (open procedure - framework contract)	Ad-hoc activities in view of refocusing the programme and integration of a new architecture. In addition, as part of the CCA activites, it may cover	1,350,000 (specific contracts for 2020)

[14] Regulation (EU, Euratom) 2018/1046 on the financial rules applicable to the general budget of the Union, repealing Regulation (EU, Euratom) No 966/2012 (2012 Financial Regulation). Official Journal of the European Union, L 193, 30 July 2018.

Number	Subject of tender	Indicative scope	Maximum budget*
		• exploring the potential socioeconomic costs and benefits for the four SPD´s when the achievements obtained in the S2R JU have been implemented in the railway system. Expected advance in competing modes and future policy frameworks; • the migration from Status Quo to the final achievements; • an innovative methodology to analyse the costs and benefits of S2R JU's results.	
3 - contract (implementation)	Railway operators, staff and passengers expertise (open procedure framework contract)	Implementation of a 4-year framework contract with a total estimated value of EUR 2 million. The estimated respective share for 2020 amounts to EUR 1 million.	1,000,000 (specific contracts for 2020)
Total			**4,350,000**

For British candidates or tenderers: Please be aware that after the UK's withdrawal from the EU, the rules of access to EU procurement procedures of economic operators established in third countries will apply to candidates or tenderers from the UK depending on the outcome of the negotiations. In case such access is not provided by legal provisions in force candidates or tenderers from the UK could be rejected from the procurement procedure.

2.2.8.2 Prizes

Prizes can take the form of "Inducement prizes" or "Recognition prizes". Inducement prizes are a novel funding instrument and form part of the demand-side innovation approaches to support research and innovation in Horizon 2020 and may be awarded by a grant beneficiary but the amount of the prize shall not be linked to costs incurred by the winner. Recognition prizes aims to recognise past achievements and outstanding work after it has been performed. The general rule for prizes is participation by any legal entity, regardless of its place of establishment unless the nature of the prize itself implies a geographical limitation. As per the EU Financial Regulation (Article 110(3)(d), only prizes with a unit value of EUR 1 000 000 or more must be included in the AWP. Nevertheless, for transparency reasons, in 2020 the S2R JU is planning to issue the following prizes:

Prizes	Subject of prizes*	Maximum budget**
1 - Train ID	Specific Challenge: The objective of this prize is to support the implementation of achieving throught Europe a unique representation of the train and path objects. To this aim the implementation of efficient algorithms that generate a single Train ID is needed. In particular this should be associated to commercial trains in synergy with the Train ID generated in cooperation with the Joint Sector Group and Rail Net Europe (RNE). Expected Impact: The solution should demonstrate its technical validity and universality while at the same time it should provide a viable path (of measures and advantages) to overcome the possible stakeholder inertia to implement such solution in nationally driven systems.	500,000
2 TRA prizes	Shift2Rail will sponsor 3 monetary prizes for the TRA 2020 young researcher competition, to be presented at TRA 2020 in Helsinki: 1st prize = 5,000 EUR, 2nd prize = 3,000 EUR and 3rd prize = 2,000 EUR	10,000
3 InnoTrans prizes	The prizes for the 'Shift2Rail R&I Awards' in InnoTrans 2020 were: The Women in Rail R&I Award, The Decarbonisation Award, the Digitalisation Award, the Project Management Award	10,000
4 Mobility start-up prizes	Shift2Rail will sponsor the 2020 European start-up prize for mobility, co-founded by the Chair of the Transport Committee	10,000
Total		530,000

(*) The type of prize (inducement or recognition prizes), the eligibility and award criteria (when applicable) as well as the deadline for submission of applications will be announced in a latter stage
(**) indicative figures in EUR

2.2.9 Dissemination and information about projects results

The results of the calls for proposals for S2R JU Members other than the Union and open calls for proposals for non-S2R JU members will be disseminated by the S2R JU via the S2R JU website (the platform for Railway R&I), press releases, newsletters, presentations at internal (EC, S2R JU Governing Board, Scientific Committee, States Representatives Group) and external (conferences, Info days, etc.) stakeholder events, and through social media.

The S2R JU participates to the different working groups established by the European Commission on dissemination and exploitation activities, to ensure that R&I results are integrated with the overall

work performed in the rest of Horizon 2020 and where appropriate in the ERA activities. It is important to remind that access to information should be always driven by two principles: the need to be able to track and have access to all past information, while at the same time creating opportunities for further dissemination.

In addition to the events the S2R JU is organising during 2020 (e.g. S2R 2020 Information Day), the main event where the S2R JU results will also be presented is InnoTrans 2020, taking place on 22-25 September in Berlin. Other major events in which the S2R JU will show its results include the TRA 2020 (27-30 April) in Helsinki, and TEN-T Days 2020 in Sibenik, Croatia. This will require to converge substantial budget for Communication activities and missions on these key events.

2.3 Call management rules

The S2R JU follows the rules of the European Union's Horizon 2020 framework programme (Horizon 2020) and in particular the Horizon 2020 Rules for participation[15] which apply, unless specified otherwise, to both calls for proposals addressed to S2R JU members other than the Union and open calls for proposals addressed to non-S2R JU members.

2.3.1 Types of calls for proposals

Article 25 of Horizon 2020 Framework Regulation provides that "(…) *public-private partnerships shall make public funds accessible through transparent processes and mainly through competitive calls, governed by rules for participation in compliance with those of Horizon 2020. Exceptions to the use of competitive calls should be duly justified*".

In light of this and considering that by the end of the duration of the S2R JU Programme the Union financial contribution to the S2R JU shall be allocated in accordance with Article 17(a), (b) and (c) of the S2R JU Statutes, the S2R JU will publish the necessary calls.

Following the simplification provisions introduced by the Commission on the implementation of Horizon 2020, the S2R JU has decided to enter in a test phase making use of lump sum grants for the call open to its members other than the Union. The lump sum approach was implemented in 2018 fixing an overall ceiling per topic and leaving it to the candidates submitting proposals to define the level of resources to be requested to achieve the call topic objectives. The use of lump sum will introduce administrative simplification during the reporting phase, while ensuring that the focus will be on R&I progress and content results.

Considering the lessons learned from the implementation of lump sum pilot during the 2018 evaluation and first reporting period, the S2R JU may propose to further continue in 2020 with Call for proposals that will take the form of lump sums as defined in Commission Decision C(2017) 7151 of 27 October 2017[16].

In addition, as already foreseen in calls of previous years, in 2020 the S2R JU Grant Agreements will also include the options regarding 'complementary grants' of the S2R JU Model Grant Agreement and

[15] http://ec.europa.eu/research/participants/data/ref/h2020/legal_basis/rules_participation/h2020-rules-participation_en.pdf

[16] Commission Decision on authorising the use of reimbursement on the basis of a lump sum for the eligible costs of actions under the Horizon 2020 Framework Programme for Research and Innovation and under the Research and Training Programme of the European Atomic Energy Community (2014-2018). http://ec.europa.eu/research/participants/data/ref/h2020/other/legal/lump_sum/lumpsumdecision_en.pdf

the provisions therein, including with regard to additional access rights to background and results for the purposes of the complementary grant(s). This should ensure the complementary of activities performed in the calls in the interest of the Programme and independently from the nature of the beneficiary. In this respect and as far as possible, the S2R JU may implement the "complementary" concept between calls launched in different years, if deemed necessary for the overall achievement of the objectives of the IPs and/or CCAs.

Complementarity between particular topics is specified within their scope, in Annexes I and II to this AWP 2020.

2.3.2 List of countries eligible for funding

Part A of the General Annexes to the European Commission (EC) Horizon2020 Work programme 2018-2020 applies[17].

2.3.3 Standard admissibility conditions and related requirements

Part B of the General Annexes to the EC Horizon2020 Work Programme 2018-2020 applies.[18]

2.3.4 Standard eligibility conditions

In line with the distinction between different types of calls for proposals, presented in Section 2.2.4, the S2R JU will distinguish between two types of calls for proposals with specific eligibility conditions:

- competitive calls for proposals, which, pursuant to Article 9.5 of Horizon 2020 Rules for Participation and Article 17.1(a) and (b) of S2R JU Statutes, will restrict the type of beneficiary to S2R JU Members other than the Union (founding and associated), and their affiliated entities. In the case of Members (other than the Union) in the form of consortia or groupings of legal entities, the individual constituent entities of these consortia or groupings, and the affiliated entities of these individual constituent entities, are eligible to participate in the restricted calls for S2R JU Members;
- and open, competitive calls for proposals that, pursuant to Article 9.5 of Horizon 2020 Rules for participation, will be addressed only to entities that are not Members of the S2R JU (founding or associated), nor constituent entities of Members in the form of consortia or groupings, nor affiliated entities either to the S2R JU Members or to the constituent entities of Members in the form of consortia or groupings.

The full list of S2R JU Members and, in the case of Members in the form of consortia or groupings of legal entities, the individual constituent entities of these Members can be found in Annex IV.

Furthermore, Part C of the General Annexes to the EC Horizon 2020 Work Programme 2018-2020 applies[19].

[17] http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018-2020/annexes/h2020-wp1820-annex-ga_en.pdf

[18] http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018-2020/annexes/h2020-wp1820-annex-ga_en.pdf

[19] http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018-2020/annexes/h2020-wp1820-annex-ga_en.pdf

Within the call for proposal for S2R JU Members other than the Union, in the case of S2R JU Members comprised of several legal entities, such legal entities shall not be deemed independent[20] of each-other in the sense of the eligibility conditions for participation set out in Part C.

NOTICE

Please note that until the UK leaves the EU, EU law continues to apply to and within the UK, when it comes to rights and obligations; this includes the eligibility of UK legal entities to fully participate and receive funding in Horizon 2020 actions such as those called for in this work programme. Please be aware however that the eligibility criteria must be complied with for the entire duration of the grant. If the UK withdraws from the EU during the grant period without concluding an agreement with the EU ensuring in particular that British applicants continue to be eligible, they will no longer be eligible to receive EU funding and their participation may be terminated on the basis of Article 50 of the grant agreement.

2.3.5 Types of action: specific provisions and funding rates

Part D of the General Annexes to the EC Horizon 2020 Work Programme for 2018-2020 applies.[21]
This means that the funding rate for grants will be 100% of the total eligible costs for research and innovation actions (RIA) and coordination and support actions (CSA), and 70% of the total eligible costs for innovation actions (IA) (except for non-profit legal entities where a rate of 100% applies)[22].

2.3.6 Evaluation rules[23]

Part H of the General Annexes to the EC Horizon 2020 Work Programme 2018-2020 applies.[24]
Selection criteria include 'financial capacity' and 'operational capacity'. Award criteria include 'excellence', 'impact' and 'quality and efficiency of the implementation'.

For full proposals, each award criterion will be scored out of 5. The threshold for individual criteria will be 3. The overall threshold, applying to the sum of the three individual scores, will be 10. For innovation actions, to determine the ranking, the score for the criterion ‘impact’ will be given a weight of 1.5.

Proposals submitted within the call for proposals for S2R JU members other than the Union or within the open call for proposals for non-S2R JU members will be evaluated by independent experts, as foreseen by the S2R JU Regulation in its Article 17.2. The evaluation of award criteria will take into account the coherence of the proposal with the S2R MAAP.

Details on the submission and evaluation process are described in the Grants Manual - Section on: Proposal submission and evaluation.

[20] Art.8 of the H2020 Rules for Participation

[21] http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018-2020/annexes/h2020-wp1820-annex-ga_en.pdf

[22] As set out in Article 28(5) of Regulation (EU) No 1290/2013, the 70% upper limit for innovation actions does not apply to non-profit legal entities.

[23] Grants Manual at https://ec.europa.eu/research/participants/docs/h2020-funding-guide/index_en.htm

[24] http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018-2020/annexes/h2020-wp1820-annex-ga_en.pdf

2.3.7 Budget flexibility

Part I of the General Annexes to the EC Horizon 2020 Work Programme 2018-2020 applies.[25]

2.3.8 Financial support to third parties

Part K of the General Annexes to the EC Horizon 2020 Work Programme 2018-2020 applies for actions performed by non-S2R JU members, supported by the S2R JU[26].Part K of the General Annexes to the EC Horizon2020 Work Programme 2018-2020 applies for actions performed by S2R JU members, supported by the S2R JU.[27]

2.3.9 Consortium agreement

The legal entities wishing to participate in a project shall form a consortium and appoint one of its members to act as its coordinator. They will conclude a Consortium agreement among themselves prior to the signature of the Grant agreement.

Following the introduction of the Lump Sum Pilot with the call of 2018, the respective Consortium Agreements should ensure to accommodate the new process in accordance with the changed provisions in the Lump Sum Grant Agreement.

2.3.10 Dissemination and information about projects results

Part L of the General Annexes to the EC Horizon 2020 Work Programme 2018-2020 applies for actions performed by non-S2R JU Members, supported by the S2R JU[28]. Part L of the General Annexes to the EC Horizon 2020 Work Programme 2018-2020 applies for actions performed by S2R JU Members, supported by the S2R JU.[29]

In addition to the dissemination of the results already foreseen in the Horizon 2020 portals, the results of the S2R JU calls will be disseminated by the S2R JU in accordance with the Communication Strategy adopted by the Executive Director in September 2017.

Together with the Scientific Committee, the S2R JU will investigate as well the possibility to disseminate and showcase the emerging S2R JU findings and impacts through key academic journals.

With regard to topics related to TSI, on the one hand, the ERA will ensure the necessary resources are made available to facilitate and accelerate dissemination. On the other hand, the S2R JU will provide the necessary material in a timely manner. Dissemination success is the result of a strong commitment towards innovation.

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[25] http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018-2020/annexes/h2020-wp1820-annex-ga_en.pdf

[26] http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018-2020/annexes/h2020-wp1820-annex-ga_en.pdf

[27] http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018-2020/annexes/h2020-wp1820-annex-ga_en.pdf

[28] http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018-2020/annexes/h2020-wp1820-annex-ga_en.pdf

[29] http://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018-2020/annexes/h2020-wp1820-annex-ga_en.pdf

As already mentioned, the S2R JU will participate in the activities of the new working groups of the Dissemination and Exploitation Network (D&E-Net). The D&E is a Horizon 2020 interinstitutional group created to coordinate and facilitate the exchange of best practices for project management between the Joint Undertakings through the creation of a dedicated collaborative platform as well as the organization of joint meetings. D&E-Net will regulary submit progress reports to the Common Support Centre Executive Committee.

2.4 Support to Operations

2.4.1 Communication and events

In order to ensure strong engagement from a wide range of stakeholders, communication must be truly integrated into the overall framework of the S2R JU Programme.

Communication on S2R JU results and their impact on citizens' everyday lives will be one of the focus points of the S2R JU's efforts in 2020. Actions in this area aim to support and demonstrate the added-value of the S2R JU R&I Programme.

A major point of attention in communication activities will be the need to ensure the involvement of stakeholders from the entire rail value chain, including actors from outside the traditional rail sector.

S2R JU communication activities aim to:

- **Continue to raise awareness about the S2R JU** among key stakeholders across Europe from the rail sector and beyond, given the ambition of a better integration of rail with other modes for both passengers and freight managers.
- **Support and promote the recognition of S2R JU results at global level** to contribute to the competitiveness of the European railway industry.
- **Promote stakeholder engagement** along and across the value chain in order to facilitate cooperation and knowledge exchange. This objective will require the organisation of fora and conferences on specific topics stemming from the Innovation Programmes.
  Both of the two aforementioned objectives will require close work with different stakeholders and their associations.
- **Promote S2R JU within the EU Institutional arena**. This objective consists of maintaining and further developing political support for S2R JU from the EU institutions and EU Member States through the promotion of S2R JU, its objectives and achievements. Target audiences for this objective includes the European Parliament and/or the Council and policy makers in EU Member States. This objective might require the organisation of events inside the European Parliament, participation in visibility events such as exhibitions, Open Days, and the production of publications and presentations of key achievements.
- **Promote the S2R JU vision and the MAAP Parts A and B**, around which the long-term vision of the sector beyond S2R JU Membership is built.
- **Lead a coherent dissemination strategy** regarding projects' activities and achievements, notably via coordinating web, documents and event management of the projects, and their presence on the S2R JU website as well as providing information to projects on Horizon 2020 dissemination tools.
- **Mobilise applicants for S2R JU open calls for proposals and/or for tenders** across Europe, ensuring a balanced representation of Member States and actors from different stakeholder groups. This will also include the organisation of the S2R JU Info Day in Brussels, once the S2R JU call for proposals is open.

- Pro-actively **publish communication material** with regard to external events and meetings related to the S2R JU. A broad dissemination of factsheets, leaflets and brochures will enhance the visibility of the S2R JU towards other stakeholders, including the general public.
- **Establish and develop a network of press and media contacts** in order to achieve considerable visibility in both specialised and general media. This network could be useful to provide visibility to the publication of press releases and specific articles related to S2R JU's activities.
- **Manage the S2R JU website, newsletters and social media platforms** in order to stimulate the public interaction on key issues and improve public awareness on S2R JU activities.

Further to the above, the S2R JU will rely on key multipliers:

- S2R JU Members, including S2R JU project coordinators, corporate Communication managers and project participants, who will communicate the success of the S2R JU to various audiences;
- ERRAC members, including policy makers and decision makers;
- Members of the Scientific Committee (SC);
- Local stakeholders;
- Members of the SRG;
- Wider stakeholders reached through S2R JU Information days and online channels Global stakeholders present at key events, within and outside the Union;
- European railway associations, including those in relation to passengers and staff;
- S2R JU staff acting as ambassadors.

The implementation of the communication activities will continue to be supported through a framework contract established with a communication agency/ies, as well as through inter-institutional framework contracts put in place by the European Commission.

2.4.2 Procurement and contracts

In order to reach its objectives and adequately support its operations and infrastructures, the S2R JU will allocate funds to procure the necessary services and supplies. In order to make procurement and contract management as effective and cost-efficient as possible, the S2R JU makes use of Service Level Agreements (SLAs) concluded with relevant Commission Services and inter-institutional framework contracts (FWC) available to them.

In 2020, the S2R JU foresees to run several procurement procedures for middle or low-value contracts [30], implement existing FWC and select individual exteral experts based on a Call for expression of interest (CEI).

Indicative Title	Indicative expenditure (EUR)	Type of procedure	Indicative schedule
Communication and event services and supplies	600,000	Middle or low-value contracts or specific Contracts/order forms implementing a FWC	1Q, 2Q, 3Q and 4Q 2020
Subscriptions to journals & periodicals	Max. 10,000	Negotiated procedure for low-value contracts	Yearly

[30] According with Article 33(3) of the new S2R JU Financial Rules adopted by the Governing Board's Decision n° 21/2015 , for contracts with a value between EUR 60,000 and the thresholds laid down in Article 175 of Regulation (EU, Euratom) 2018/1046 the procedure set out in Section 2 of Annex I of Regulation (EU, Euratom) 2018/1046 for contracts with a low value not exceeding EUR 60,000 may be used.

Indicative Title	Indicative expenditure (EUR)	Type of procedure	Indicative schedule
Assistance and support of external experts	85,000	Ad-hoc expert contracts, not for call evaluation nor review, based on a CEI; specific contracts to implement a FWC for strategic support (estimated at EUR 0.5 million in 4 years)	1Q, 2Q, 3Q and 4Q 2020
Basic office furniture	<15,000	Specific Contracts/order forms implementing a FWC	1Q, 2Q, 3Q and 4Q 2020
Catering services	50,000	Low-value contracts or specific Contracts/order forms implementing a FWC	1Q, 2Q, 3Q and 4Q 2020
IT support and supplies	145,000	Specific Contracts/order forms implementing a FWC or Negociated procedure for middle or low value contract	1Q, 2Q, 3Q and 4Q 2020
Team Building and Training	50,000	Negociated procedure for low value contract or Specific Contracts/order forms implementing a FWC	1Q, 2Q, 3Q and 4Q 2020
Finance and audit	25,000	Specific Contracts/order forms implementing a FWC	1Q, 2Q, 3Q and 4Q 2020
Legal Assistance	50,000	Specific Contracts/order forms implementing a FWC	1Q, 2Q, 3Q and 4Q 2020

This list shall not be considered exhaustive and other procurement procedures may need to be launched within the budgetary limits approved by the S2R JU Governing Board. The Executive Director shall report to the Governing Board about the procedures put in place as part of the AAR 2020.

2.4.3 IT and logistics

The S2R JU has implemented common ICT tools designed and offered by the European Commission on the financial management and Horizon 2020 call management. These tools are updated and maintained on a regular basis by the EC; they require continuous input from the side of the S2R JU, on the one hand, in terms of future developments to meet the expectations of the partnership and, on the other hand, to correct mistakes.

Since 2018, the S2R JU has implemented ARES (EC document management system) in order to streamline document flow as well as to ensure their proper archiving and registration and SYSPER for staff administration in Q1 2019, thereby leveraging on the existing EC infrastructure and processes.

In addition, the S2R JU is making use of the training services offered by the EC on these applications to assure their correct usage and implementation.

For the calls for proposals in the AWP 2020, the Horizon 2020 IT systems will be used for the publication of the call, the submission and evaluation of the proposals and grant preparation.

The S2R JU is collaborating with the joint strategic ICT plan of the Joint Undertakings located in the White Atrium building. During 2017, the physical infrastructure was moved to private cloud computing. During 2018, with the participation in the Inter-Agency Cloud Framework Contract led by EFSA in Parma, the S2R JU continued using the latest information technology of the cloud in order to maximize the systems uptime, resource availability and geographical accessibility. In 2020, it is expected that the dependency of the ICT systems to physical infrastrutcture in White Atrium is reduced to a minimum.

2.4.4 S2R JU Programme Team – HR matters

By 2020, the S2R JU shall be fully staffed with 24 staff members including 3 Seconded National Experts (SNEs). Indeed, the third SNE recruited for a temporary replacement proved to be a key asset in the work of the S2R JU towards the establishment of relations with European regions, contribution to the definition of standards, horizontal tasks in relation to the future deployment of the S2R JU Innovative Solutions. In addition, the presence of 3 SNEs provided the possibility for a more structured approach in the Programme implementation which allowed compensating to Contract Agents fluctuations due to their contract conditions compared to Programme Managers in other JUs, agencies or Institutions.

Further details are provided in Section 3 in the Staff Establishment Plan.

In addition to statutory staff Members and the SNE's already in place, the S2R JU will also resort to the European Commission's Bluebook trainees.The S2R JU HR function ensures continuous improvement of all HR processes and will continue to develop its internal guidelines, policies and its legal framework, paying particular attention to how EU Staff Regulations' Implementing Rules shall apply to the S2R JU particularities (in accordance with Article 110 of the EU Staff Regulations).

Annual appraisal and reclassification exercises will be set up by HR within the limits of the Staff Establishment Plan and the S2R JU Financial Rules, with the support of HR IT tool (SYSPER). Trainings for staff members will be further developed and social events will take place in order to reinforce the cohesion of the team.

2.4.5 Administrative budget and finance

The European Commission's Accrual Based Accounting system (ABAC) has been rolled out in the S2R JU in 2016 and is used for accounting purposes.

The S2R JU will implemente the new S2R JU financial rules once adopted by the S2R JU Governing Board, which define powers and responsibility of the S2R JU Accounting Officer inter alia. They also make an explicit reference to the possibility that this function could be attributed to the Accounting Officer of the EC[31].

In this respect, the S2R JU Governing Board has also appointed the Accounting Officer of the EC as the Accounting Officer to the JU. This appointment is not expected to be revised in 2020. In addition, the S2R JU Governing Board has examined at different stages the need for an internal audit capability, in addition to the Internal Audit Service of the Commission (the S2R JU Internal Auditor), and considered

[31] Commission Delegated Regulation (EU) 2019/887 on the on the model financial regulation for public-private partnership bodies referred to in Article 71 of Regulation (EU, Euratom) 2018/1046 of the European Parliament and of the Council

that the current processes and procedures provide reasonable assurance on the functioning of the organization.

2.4.6 Data protection

As regards the processing of personal data, the S2R JU applies Regulation (EU) 2018/1725 of 23 October 2018[32] which entered into force on 11 December 2018.

The role of the data protection officer (DPO) is exercised by the S2R JU's Legal Officer and it is expected to be externalized to a third party by the end of 2019. During 2020 the implementation of the new data protection regime will continue*, inter alia*, implementing the S2R JU Data Protection Action plan, drafting new S2R JU privacy statements; reviewing data processing operations; updating the data protection central register; and providing guidance to S2R JU staff.

2.5 Governance

The S2R JU is composed of two Executive bodies: the Governing Board and the Executive Director. In addition, there are two advisory bodies: the Scientific Committee and the States Representatives Group.

2.5.1 Governing Board

The S2R JU Governing Board has the overall responsibility for the strategic orientation and the operations of the S2R JU and supervises the implementation of its activities, in accordance with Article 8 of the S2R JU Statutes.

The S2R JU Governing Board was established after the 8 Founding Members of the S2R JU other than the Union listed in Annex II to the S2R Regulation, endorsed the S2R JU Statutes and once all founding members, including the Union, nominated their representatives and alternate representatives to the Board.

In accordance with Art. 6 of the S2R JU Statutes, once the process of selection of the Associated Members was completed in late 2015, the representatives of the Associated Members to the S2R JU Governing Board were selected, after nomination by the IP Steering Committees and appointment by the Board. Following this process, the final composition of the S2R JU Governing Board was reached beginning of 2016. The Governing Board is currently composed of two representatives from the Commission, one representative from each of the 8 founding members of the S2R JU other than the Union, and 10 representatives of associated members. The remaining Associated Members can attend the meeting of the S2R JU Governing Board as observers.

In line with the provisions of the S2R JU Statutes, a representative of the ERA and the chairperson or the vice-chairperson of the States Representatives Group will have the right to attend meetings of the S2R JU Governing Board as observers and take part in its deliberations, but with no voting rights. The chairperson of the Scientific Committee will be invited to attend meetings of the S2R JU Governing Board as an observer and take part in its deliberations, whenever issues falling within its remit are discussed, but has no voting rights.

In 2020, the S2R JU Governing Board is planning to hold three ordinary meetings.

[32] Regulation (EU) 2018/1725 of the European Parliament and of the Council of 23 October 2018 on the protection of natural persons with regard to the processing of personal data by the Union institutions, bodies, offices and agencies and on the free movement of such data, and repealing Regulation (EC) No 45/2001 and Decision No 1247/2002/EC

The key activities are listed below:

Key activities in 2020 – timetable	
Approve 2019 Annual Activity Report	Q1
Decision on proposals for funding from call 2020	Q2/Q3
Discuss draft 2021 Annual Work Plan	Q4
Discuss draft budget 2021	Q4
Adopt the key documents for the S2R JU's operations in 2021: 2021 budget and staff establishment plan	Q4

2.5.2 Executive Director

According to Article 10 of the S2R JU Statutes, the Executive Director is the chief executive responsible for the day-to-day management of the S2R JU in accordance with the decisions of the Governing Board. The Executive Director is the legal representative of the S2R JU. The Executive Director is accountable to the Governing Board. He is supported by the S2R JU staff.

2.5.3 Scientific Committee

According to Article 13 of the S2R JU Statutes, the Scientific Committee is an advisory body to the S2R JU Governing Board. During the year 2020, two meeting of this body are planned.

The tentative key activities are listed below:

Key activities in 2020 – timetable	
13th Meeting of the SC. The SC would: – Provide advice on the planned calls for proposals and/or for tenders. – Provide advice on the results achieved in the previous years and the alignment with the MAAP.	Q2
14th Meeting of the SC. The SC would: – Provide advice on the scientific priorities to be addressed in the 2021 Annual Work Plan, including links with similar research activities carried out for example in Horizon 2020 and linking to Horizon Europe. – Provide advice to the S2R JU GB on the programme progress of the S2R JU and other strategic issues.	Q4

As implemented since 2019, the possibility will also exist in 2020 to contract Scientific Committee Members as experts in the review and monitoring of the S2R JU Projects.

2.5.4 States Representatives Group

Following the entry into force of the S2R JU Regulation, Members States and countries associated to the Horizon 2020 framework programme were asked to nominate their representatives to the States Representatives Group (SRG), in accordance with Article 14 of the S2R Statutes. To date, 33 countries have nominated representatives to the Group.

The States Representatives Group shall be involved in particular in the review of information and provision of opinions on the following matters:

- strategic orientation, the S2R Master Plan, and progress towards achievement of the S2R JU targets;
- the S2R JU Annual Work Plans;
- links to Horizon 2020/Horizon Europe and to other Union and Member State funding instruments, including the Connecting Europe Facility and the European Structural and Investment Funds;
- links to the Union rail transport legislation and the goal of achieving a Single European Railway Area;
- involvement of SMEs and relevant actors from outside the traditional rail sector.

The States Representatives Group also provides information to, and acts as an interface within the S2R JU on the following matters:

a) the status of relevant national or regional research and innovation programmes and identification of potential areas of cooperation, including deployment of relevant technologies to allow synergies and avoid overlaps;
b) specific measures taken at national or regional levels with regard to dissemination events, dedicated technical workshops and communication activities.

The States Representatives Group may issue, on its own initiative, recommendations or proposals to the S2R JU Governing Board on technical, managerial and financial matters as well as on annual work plans, in particular when those matters affect national or regional interests.

During the year 2020, two meetings of the States Representatives Group are planned (Q2 and Q4).

The tentative key activities are listed below:

Key activities in 2020 – timetable	
12th Meeting of the SRG. The SRG would: – Provide advice on the draft 2021 Annual Work Plan. – Provide advice on the planned calls for proposals. – Provide advice on the results achieved in the previous years and the alignment with the MAAP.	Q2
13th Meeting of the SRG. The SRG would: – Provide advice on the priorities to be addressed in the 2021 Annual Work Plan, including links with similar research activities carried out for example in Horizon 2020 – Provide advice to the S2R JU GB on the programme progress of the S2R JU and other strategic issues – Provide updated information and discuss initiatives on: regional and national research and innovation programmes to allow synergies; dissemination and communication activities; and deployment activities in relation to S2R JU.	Q4

As the new Chairperson and Vice-Chairperson of the SRG were elected as of 1st January 2019 for a period of two years, a new election will be orgnaized end of 2020 for the new mandates starting as of 1st January 2021.

2.6 Internal Control framework

2.6.1 Financial procedures

In 2016, S2R JU adopted an ICT tool, ABAC Workflow, to support its financial procedures. At the same time, it adopted its Manual of Financial Procedures including the Financial Circuits applicable to the S2R JU. This Manual of Financial Procedures was further revised in a new version in 2017.

The Manual of Financial Procedures has been designed to guarantee a segregation of duties and to apply the four eyes principle in S2R JU financial transactions. It describes in detail the financial circuits the S2R JU implements per type of transactions and the roles and responsibilities of each actor involved. To a lesser extent, it also describes the basic principles on main procedures (grants & procurements).

During the past years, the processes and procedures have been further reinforced with the introduction of the S2R JU Cooperation Tool (including for in-kind contribution declarations and certifications), the Governance and Process Handbook, implementation of ICT tool ABAC Assets and different specific procedures that enhance the sound financial management in the implementation of the activities. During 2019, the S2R JU has implemented most of the remaining elements of the Internal Control System which has been in place since 2016.

In 2020, in accordance with the Financial Regulation 2018, the S2R JU expects the implementation of a revised Internal Control Framework, following the Commission approach for the revision of the Internal Control Framework (cf. C(2017) 2373 Final). The impact of the new internal control framework on the S2R JU financial procedures will be assessed, and further adjustments may be introduced, also taken into account experience gained with the implemention of these processes and procedures.

2.6.2 Ex-ante and ex-post controls

The S2R JU follows the procedures for ex-ante and ex-post control established in its Financial Rules as well as guidelines applicable to Horizon 2020.

The S2R JU is aligning *with the Article 21 of the new S2R Financial Rules* providing that "Each operation shall be subject at least to an ex ante control based on a desk review of documents and on the available results of controls already carried out relating to the operational and financial aspects of the operation". The ex-ante controls are considered essential to prevent errors and to avoid the need for ex-post corrective actions. They take the form of checking contracts and grant agreements, initiating, checking and verifying invoices and cost claims and carrying out desk reviews (such as mid-term reviews carried out by external experts on S2R JU projects and other). In addition to the process' defined internally, the S2R JU is implementing the Horizon 2020 ex-ante control framework for its grants.

Ex-post controls are defined as the controls executed to verify financial and operational aspects of finalised budgetary transactions *in accordance with Article 22 of the S2R JU Financial Rules*. The main objectives of the ex-post controls are to ensure that the principles of legality, regularity and sound financial management (economy, efficiency and effectiveness) have been respected and to provide the basis for corrective and recovery activities, if necessary.

The S2R JU ex post controls of S2R JU projects include financial audits which are covered by the Horizon 2020 Audit Strategy and administrated by the Common Audit Service (CAS) of the Commission. In 2020, the S2R JU will report the outcome of the ex-post audits performed on the S2R JU specific sample on its validated cost claims. This reporting will include the error rates identified and applicable to the JUs population.

In addition, the S2R JU has introduced since 2018 an internal mechanism of ex-post controls on financial transactions related to administrative expenditure as another element in the control framework to provide assurance on the effective functioning of the system.

In 2020, the ex-post review on administrative expenditure will be organised on an annual basis.

2.6.3 Audits

In accordance with the Article 26 of the Financial Rules applicable to the S2R JU, the internal audit function shall be performed by the Commission's Internal Auditor.

The internal auditor shall advise the S2R JU on dealing with risks, by issuing independent opinions on the quality of management and control systems and by issuing recommendations for improving the conditions of implementation of operations and promoting sound financial management.

The financial audit of the S2R JU accounts is performed by an external audit firm that has been chosen under the Framework contract of DG Budget, on the basis of the joint tendering of the services by the EC, agencies and other JUs.

Each year, the European Court of Auditors shall prepare a specific annual report on the S2R JU in line with the requirements of Article 287(1) of the Treaty on the Functioning of the European Union. In preparing the report, the Court shall consider the audit work performed by the aforementioned independent external auditor and the action taken in response to his or her findings.

Regarding the ex-post audits on grants, the S2R JU is part of the Horizon 2020 common Audit Strategy. The strategy has been developed and implemented by the Common Audit Service of the Commission, as mentioned in the previous section.

2.6.4 Risk Management

During 2020, in accordance with the S2R JU Policy for Risk Management as defined in the Governance and Process Process Handbook, the S2R JU will perform a risk assessment exercise to ensure that the internal control system in place provides the reasonable assurance to achieve the strategic objectives of its Programme, as established in the Master Plan and MAAP. This process will also reflect the implementation of the new Internal Control Framework during 2020.

3. BUDGET 2020

3.1 Budget information

The S2R JU 2020 Budget is subject to the adoption of the EU General Budget for 2020 and to the adoption of the S2R JU Governing Board. All figures may be updated during both of these adoption procedures.

The present Budget is based on the initial amounts submitted to the Commission Services in view of the preparation of the Union Draft Budget 2020, duly updated taking into account the final budget availabilities. It might be subject to adjustments considering the appropriations made available by the Union and to amendments to take into account any unexpected elements. Any possible Budget amendment will be subject to the S2R JU Governing Board approval on a proposal from the Executive Director.

Revenue

The S2R JU details three types of revenue in its Budget 2020:

- The contributions from the Union, including the EFTA contribution;
- The contributions from the members other than the EU;
- The un-used appropriations from the previous years.

The revenue includes EUR 0.5 million relating to the Expert Evaluators; this amount, although included in the S2R JU Budget, is managed by the REA Services. Unused amounts will be returned to the S2R JU.

Expenditure

The amount included in the 2020 Budget takes into account the overall ceiling established in the S2R JU Regulation on the total amount of the S2R JU Running Costs till 2024.

Staff Expenditure (Title 1)

Title 1 includes the following Chapters:

- The full cost of staff in Active Employment for Temporary Agent Staff (110) and Contractual Agents, Interim Staff, trainees and SNEs (111);
- Mission Costs (13);
- Training (15);
- Other Staff Expenditure (19), such as medical service, recruitment, mobility costs and other social expenses.

The estimated expenditure under Title 1 amounts to EUR 2,477,000 and represents 70% of the total administrative budget. A majority of this amount covers the Salaries & allowances of the S2R JU staff.

Administrative Expenditure (Title 2)

The S2R JU details its staff expenditure into following Chapters to cover the costs of:

- Rental of buildings and associated costs (20)
  Amongst which: Rents; Provisions for other charges in relation to housing
- IT Expenditure and technical facilities (21)
  Amongst which: Hardware purchases; Software development & purchases; Day-to-day maintenance
- Movable property and associated costs (22)
  Amongst which: The purchase / maintenance of office equipment and furniture

- Current Administrative Expenditure (23)
  Amongst which: Stationery and office supplies; Petty expenditure; Documentation and library expenditure, subscriptions; Translation, interpretation

- Postage and telecommunications (24)
  Amongst which: postage, telephone, internet and mobile communication expenses

- Administrative Board Expenditure (25)
  Amongst which: Governing Boards, SRG meetings, SC meetings and other meeting expenditure

- Administrative support services (26)
  Amongst which: Experts other than ones related to evaluations and project reviews under operational budget, Beneficiary portal.

- PR and Events (27)
  Amongst which: All communication costs of the JU, design and printing or promotional items, organising and attendance of events, website

- Other Infrastructure and operating Expenditure (29)
  Amongst which; auditing, studies, ABAC fees and other service fees to support the JU infrastructure

Operational expenditure (Title 3)

This chapter includes all operational expenditure of the S2R JU necessary to implement the R&I activities described in the present document.

As already indicated with regard to the Revenues, this chapter also includes EUR 0.5 million relating to the Expert Evaluators which is managed by the REA Services.

Un-used Appropriations not required in current year (Title 4)

Budget year 2020 is the last year for the S2R JU to collect the Commitment Appropriations available under the Horizon 2020 funding scheme from the Union. Therefore, the S2R JU will use the full contribution as foreseen in the S2R JU Regulation to allow the running of activities until 2024. The Commitment Appropriations required to run the S2R JU after 2020 are placed under Title 4 to be available for re-activation in future budget years. In addition, the previously transferred credits of EUR 1.3 million from Administrative Budget to the Operational Budget is returned to the Administrative lines in 2020. These two facts increase the amount recorded under Title 4 in this budget year.

Shift2Rail Joint Undertaking Budget 2020

STATEMENT OF REVENUE

Title / Chapter	Heading	2018 Budget Executed CA	2018 Budget Executed PA	% of Budget 2020 CA	% of Budget 2020 PA	2019A1 Budget CA	2019A1 Budget PA	2020 Budget CA	2020 Budget PA	CA Variance 2019/2020 EUR	CA Variance 2019/2020 %	PA Variance 2018/2019 EUR	PA Variance 2018/2019 %
9	REVENUE												
90	CONTRIBUTIONS												
	CONTRIBUTION FROM THE EUROPEAN UNION	79.227.979	77.503.542	97%	102%	79.982.327	62.866.928	81.839.584	75.997.838	1.857.257	2,3%	13.130.910	20,9%
900	*Administrative Budget*	*1.661.839*	*1.661.839*	*31%*	*157%*	*1.661.627*	*1.661.627*	*5.317.621*	*1.056.000*	*3.655.994*	*220,0%*	*(605.627)*	*(36,4%)*
901	*Operational Budget*	*77.566.140*	*75.841.703*	*101%*	*101%*	*78.320.700*	*61.205.301*	*76.521.963*	*74.941.838*	*(1.798.737)*	*(2,3%)*	*13.736.537*	*22,4%*
	CONTRIBUTION FROM MEMBERS OTHER THAN THE EU	1.661.839	1.661.839	97%	157%	1.661.627	1.661.627	1.706.000	1.056.000	44.373	2,7%	(605.627)	(36,4%)
902	*Administrative Budget*	*1.661.839*	*1.661.839*	*97%*	***157%***	*1.661.627*	*1.661.627*	*1.706.000*	*1.056.000*	*44.373*	*2,7%*	*(605.627)*	*(36,4%)*
93	UN-USED APPROPRIATIONS PREVIOUS YEARS*	3.866.664	2.474.382	172%	97%	1.121.332	16.728.472	6.131.377	3.201.048	5.010.045	446,8%	(13.527.424)	(80,9%)
930	*Un-used appropriations previous years Administrative*	*1.359.401*	*2.474.382*	*-*	*-*	*688.899*	*1.033.626*	*519.521*	*639.699*	*(169.378)*	*(24,6%)*	*(393.927)*	*(38,1%)*
931	*Un-used appropriations previous years Operational*	*2.507.263*	*-*	*111%*	*0%*	*432.433*	*15.694.846*	*5.611.856*	*2.561.349*	*5.179.423*	*1.197,7%*	*(13.133.497)*	*-0,836803*
REVENUE		84.756.482	81.639.763	99%	103%	82.765.286	81.257.027	89.676.961	80.254.886	6.911.675	8,4%	(1.002.141)	(1,2%)

STATEMENT OF EXPENDITURE

Title / Chapter	Heading	2018 Budget Executed CA	2018 Budget Executed PA			2019A1 Budget CA	2019A1 Budget PA	2020 Budget CA	2020 Budget PA	CA Variance 2018/2019 EUR	CA Variance 2018/2019 %	PA Variance 2018/2019 EUR	PA Variance 2018/2019 %
1	**STAFF EXPENDITURE**												
11	STAFF IN ACTIVE EMPLOYMENT	1.899.761	1.829.798	87%	84%	1.970.000	2.052.277	2.180.000	2.180.000	*210.000*	*10,7%*	*127.723*	*6,2%*
110	*Temporary Agents*	*678.656*	*678.656*	*92%*	*92%*	*701.000*	*701.000*	*740.000*	*740.000*	*39.000*	*5,6%*	*39.000*	*5,6%*
111	*Contract Agents, Interim Staff, trainees and SNEs*	*1.221.105*	*1.151.142*	*85%*	*80%*	*1.269.000*	*1.351.277*	*1.440.000*	*1.440.000*	*171.000*	*13,5%*	*88.723*	*6,6%*
13	MISSION COSTS	91.003	86.989	114%	109%	60.000	66.662	80.000	80.000	*20.000*	***33,3%***	*13.338*	***20,0%***
15	TRAINING	35.421	10.849	177%	54%	30.000	30.158	20.000	20.000	*(10.000)*	***(33,3%)***	*(10.158)*	***(33,7%)***
19	OTHER STAFF EXPENDITURE	166.867	156.250	85%	79%	217.000	213.934	197.000	197.000	*(20.000)*	***(9,2%)***	*(16.934)*	***(7,9%)***
TITLE 1 TOTAL		**2.193.052**	**2.083.886**	**89%**	**84%**	**2.277.000**	**2.363.031**	**2.477.000**	**2.477.000**	***200.000***	***8,8%***	***113.969***	***4,8%***
2	**ADMINISTRATIVE EXPENDITURE**												
20	RENTAL OF BUILDINGS AND ASSOCIATED COSTS	313.609	284.468	95%	86%	320.000	328.477	330.000	330.000	*10.000*	*3,1%*	*1.523*	*0,5%*
21	IT EXPENDITURE AND TECHNICAL FACILITIES	174.854	140.757	121%	97%	171.000	211.339	145.000	145.000	*(26.000)*	*(15,2%)*	*(66.339)*	*(31,4%)*
22	MOVABLE PROPERTY AND ASSOCIATED COSTS	1.387	34.039	9%	227%	15.000	5.857	15.000	15.000	*0*	*0,0%*	*9.143*	*156,1%*
23	CURRENT ADMINISTRATIVE EXPENDITURE	12.000	13.629	60%	68%	25.000	26.628	20.000	20.000	*(5.000)*	*(20,0%)*	*(6.628)*	*(24,9%)*
24	POSTAGE AND TELECOMMUNICATIONS	17.000	5.495	85%	27%	25.000	11.310	20.000	20.000	*(5.000)*	*(20,0%)*	*8.690*	*76,8%*
25	ADMINISTRATIVE BOARD EXPENDITURE	53.178	46.356	106%	93%	40.000	38.439	50.000	50.000	*10.000*	*25,0%*	*11.561*	*30,1%*
26	ADMINISTRATIVE SUPPORT SERVICES	15.000	40.078	18%	47%	60.000	59.674	85.000	85.000	*25.000*	*41,7%*	*25.326*	*42,4%*
27	PR AND EVENTS	502.279	630.013	167%	210%	450.000	545.141	300.000	300.000	*(150.000)*	*(33,3%)*	*(245.141)*	*(45,0%)*
29	OTHER INFRASTRUCTURE AND OPERATING EXPENDITURE	100.720	98.909	101%	99%	109.632	127.284	100.000	100.000	*(9.632)*	*(8,8%)*	*(27.284)*	*(21,4%)*
TITLE 2 TOTAL		**1.190.027**	**1.293.744**	**112%**	**121%**	**1.215.632**	**1.354.150**	**1.065.000**	**1.065.000**	***(150.632)***	***(12,4%)***	***(289.150)***	***(21,4%)***
TOTAL ADMINISTRATIVE EXPENDITURE (Title 1 and Title 2)		**3.383.079**	**3.377.630**	**96%**	**95%**	**3.492.632**	**3.717.181**	**3.542.000**	**3.542.000**	***49.368***	***1,4%***	***(175.181)***	***(4,7%)***

STATEMENT OF EXPENDITURE

Title / Chapter	Heading	2018 Budget Executed CA	2018 Budget Executed PA			2019A1 Budget CA	2019A1 Budget PA	2020 Budget		CA Variance 2019/2020 EUR	CA Variance 2019/2020 %	PA Variance 2018/2019 EUR	PA Variance 2018/2019 %
3	OPERATIONA EXPENDITURE												
30	OPERATIONAL EXPENDITURE	81.373.403	55.777.303	101%	73%	78.753.133	76.900.147	80.833.819	76.203.187	*2.080.686*	2,6%	*(696.960)*	*(0,9%)*
TITLE 3 TOTAL		**81.373.403**	**55.777.303**	**101%**	**73%**	**78.753.133**	**76.900.147**	**80.833.819**	**76.203.187**	***2.080.686***	**2,6%**	***(696.960)***	***(0,9%)***
4	UNUSED APPROPRIATIONS NOT REQUIRED IN CURRENT YEAR												
40	ADMINISTRATIVE BUDGET	-	1.120.430	0	2,1982	519.521	639.699	5.301.142	509.699	*4.781.621*	920,4%	- *130.000*	*-20%*
41	OPERATIONAL BUDGET	-	21.364.400	0	0	-	-			*0*	0%	*0*	*0,0%*
TITLE 4 TOTAL		**0**	**22.484.830**	**0**	**44,114**	**519.521**	**639.699**	**5.301.142**	**509.699**	***4.781.621***	**920,4%**	***(130.000)***	***(20,3%)***
TOTAL EXPENDITURE		**84.756.482**	**81.639.763**	**95%**	**102%**	**82.765.286**	**81.257.027**	**89.676.961**	**80.254.886**	***6.911.675***	**8,4%**	***(1.002.141)***	***(1,2%)***

Contributions overview

CONTRIBUTIONS OVERVIEW	2018	2019	2020
CONTRIBUTIONS FROM THE UNION (incl EFTA)	**79,227,979**	**79,982,327**	**81,839,584**
Title 1 and Title 2 (financial)	1,661,839	1,661,627	5,317,621
Title 3 (financial)	77,566,140	78,320,700	76,521,963
CONTRIBUTIONS FROM MEMBERS OTHER THAN THE UNION	**52,478,408**	**96,577,524**	**73,939,913**
Title 1 and Title 2 (financial)	1,661,839	1,661,627	1,706,000
Title 3 (in-kind)	50,816,569	94,915,897	72,233,913
TOTAL CONTRIBUTIONS	**131,706,387**	**176,559,851**	**155,779,497**

(1) Including the Grant Agreements under Call 2018 signed in 2019

Schedule of payments

	Commitment Appropriations		Payment Appropriations	
	RAL from earlier years	Budget 2020	Budget 2020	Estimated Budget 2021 and after
2015 Work Plan Operational	0		0	0
2016 Work Plan Operational	0		0	0
2017 Work Plan Operational	8,259,383		6,424,901	1,834,482
2018 Work Plan Operational	42,512,200		32,773,478	9,738,722
2019 Work Plan Operational	42,282,883		560,000	41,722,883
2020 Work Plan Administrative		3,542,000	3,542,000	0
2020 Work Plan Operational		80,833,819	36,444,808	44,389,011

Total	**93,054,466**	**84,375,819**	**79,745,187**	**97,685,098**

3.2 Staff Establishment Plan

Establishment plan posts

Temporary posts

Function group and grade	2018				2019		2020	
	Authorised Budget		Actually filled as of 31/12/2018		Authorised Budget		Request of the Agency	
	Permanent posts	Temporary posts	Permanent posts	Temporary posts	Permanent posts	Temporary posts	Permanent posts	Temporary posts
AD 16								
AD 15								
AD 14		1		1		1		1
AD 13								
AD 12								
AD 11								
AD 10								
AD 9		2		2		2		2
AD 8		1		1		1		1
AD 7		1		1		1		1
AD 6								
AD 5								
AD TOTAL		5		5		5		5
AST 1- 11								
AST TOTAL								
AST/SC 1-6								
AST/SC TOTAL								
TOTAL		5		5		5		5
GRAND TOTAL	5		5		5		5	

Contract Agents

Contract agents	Authorised 2018	Recruited as of 31/12/2018	Authorised 2019	2020 Request of the Agency
Function Group IV	11	10	12	12
Function Group III	3	3	3	3
Function Group II	2	2	1	1
Function Group I				
TOTAL	16	15	16	16

Seconded National Experts

Seconded National Experts	Authorised 2018	Recruited as of 31/12/2018	Authorised 2019	2020 Request of the Agency
TOTAL	2 (1)	3	2 (1)	3
(1) 1 additional SNE is authorised by DG MOVE for initial period of one year and extended				

4. ANNEXES

4.1 ANNEX I – 2020 Call for proposals for the JU members – Topic descriptions

4.1.1 S2R-CFM-IP1-01-2020 Demonstrators for the next generation of traction systems, smart maintenance, virtual validation and eco-friendly Heating, Ventilation Air conditioning and Cooling (HVAC) and Technical research on battery and hydrogen powered regional trains (BEMU/ HMU) (IP1/IP3)

SPECIFIC CHALLENGE

There are several specific challenges concerning traction systems and HVAC.

A reference architecture for CCS will be developed in the action to be funded under topic S2R-CFM-IPX-CCA-01-2019. AWP2020 includes the continuation of these activities inside the topic S2R-CFM-IPX and CCA-02-2020. Subsequently, each CFM proposal has to be aligned with the progress in S2R-CFM-IPX-CCA-01-2019 and S2R-CFM-IPX and CCA-02-2020; in particular the system approach and interoperability of solutions must be ensured across S2R IP/CCA activities and for future developments.

1. Traction systems

The Traction Drive sub-system is one of the main sub-systems of a train as it moves the train converting energy from an electrical source (directly or via a chemical source) into a mechanical one.

The physical domains to master are multiple: electrical, mechanical, thermal, and control. A large number of norms and regulations have to be taken into account for traction systems design, manufacturing, validation and certification. The challenges, at this point, are:

- to master technologies breakthrough developments like Silicon carbide (SiC) semi-conductors applied to different railway traction applications and independent rotating wheels for HST;
- to develop and contribute to implementing new methodologies, tools, norms & standards of noise, reliability, virtual validation and certification, smart maintenance.
- Continuing and finishing the work of PINTA and PINTA2 by the Traction demonstrations on trains (Regional, Metro) using SiC technologies, Wheel motors for HST, conclude on the 7 Traction KPIs progress and consolidate results at train level.

2. HVAC

Conventional HVAC systems of rail vehicles use artificial refrigerants that have a very high impact on the global warming (e.g. R134a). To limit the climatic impact from HVAC systems, the EC passed in 2014 regulation No 517/2014 which aims to reduce the use of artificial refrigerants within the EU. Rail service operators and vehicle integrators need to act quickly due to the long lifetime of the rolling stock. Hence new and redesigned trains should be equipped with eco-friendly HVAC systems using natural gases such as air or CO_2.

The objective of this research activity in the S2R JU is the increase of technical readiness of HVAC-units with natural gases up to TRL 7 so that they can be purchased for new vehicles or for retrofitting of existing units without technical risks.

3. Battery and Hydrogen solutions

In addition to the use of renewable energies for energy supply of electrified railway lines, the use of alternative drive systems is necessary to achieve CO2-free passenger and freight traffic on non-

electrified lines. The focus of this call is regional traffic. Vehicle solutions could be “Battery Electric Multiple Units” (BEMUs) or “Hydrogen Multiple Units” (HMU). The results being developed in this call (e.g. standardized interfaces) can also be applied for freight application.

The goal of zero CO2-emission can be reached with new developed BEMUs or HMUs based on existing EMU-platforms. This is already on the way within the railway industry with first prototypes. But by considering only new trains the reduction of CO2-impact to zero emission will take more than 30 years until all running diesel trains are substituted by new BEMUs. Therefore retrofitting of existing trains is necessary to achieve the target and time line of the EU for reduction of CO2-emission. Especially for retrofitting special challenges are to overcome with respect to weight management, charging solutions and economy. Currently there is no affordable solution for an economical retrofitting available on the market and the goal of this call is to elaborate further to define these possible solutions. The topic itself is seen as a bridge between the S2R JU and activities to come within Horizon Europe and a possible follow up of the S2R JU.

A further challenge of this call is basic research for the second generation of BEMUs and HMUs targeting the operational behaviour of today’s DMU and/or EMU.

SCOPE

The main target (but not the only one) of the proposed project is to demonstrate (TRL 7) on trains, as described in the IP1 Demo Plan:

- SiC based Traction systems for Metro (on Quarter2 of 2022) and Regional (on Q4 2021 to Q1 2022) trains applications
- Wheel-motor on a HST train application (on Q4 2021)
- Complete (TRL 7 as far as methodologies and tools could be described by TRL NASA approach) methodologies and tools to simulate and predict Traction noises, reliability
- Demonstrate (TRL 7) Traction smart maintenance algorithms & health monitoring on trains.

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

1. **Work stream 1: Traction**

On traction, work should cover:

- **Traction solution developments :**
    - Based on experience gained in PINTA2, continuation of manufacturing and test (static test bench and on train tests) of new hardware and software traction components and sub-systems (especially Silicon Carbide based, but also independently rotating wheel architecture for HST) customised for different market segments (urban, regional, HST) up to TRL 7.
    - Smart maintenance (TRL 7): implement high reliability components and specific maintenance solutions per train application (Condition Based Monitoring of traction components, remote diagnostic, on-board and/or off-board software, etc.), leading up to “smart-maintenance” integrated demonstrators.
    - Continue test bench tests and assess their results on the S2R JU and PINTA defined KPIs (Capital cost, maintenance cost, energy cost, reliability, weight, volume, noise of traction system and/or traction components).

  Industrials and Operators should cooperate as much as possible in Life-Cycle Costs (LCC) and other KPIs quantification in order to support future introduction to commercial markets thanks

to very well understood capabilities, performance and costs of the new technologies developed within the S2R JU.

- **Traction Noise (TRL 7)**: Based on experience gained in PINTA2, finish the development and implementation of methodologies and tools for acoustic noise emission prediction and reduction (noise levels and tonal noise, electromagnetic, aerolic noise) for traction sub-system, components and parts (ex.: fans) in all phases of vehicle use including parking mode.

- **Traction Reliability/Availability (TRL 7)**: Based on the results of PINTA2, finish the development of methodologies and tools and increase traction system reliability, availability, in particular, use real operator data and return of experience as much as possible.

  Continue further improvements in converter reliability concerning SiC modules , train availability, smart maintenance solutions and generic approach due to digitalized system features.

  Conclude on the "data observation system" prototype in a real train environment implemented in PINTA2 on added value for reliability, availability or smart maintenance purposes.

- **Traction virtual validation & certification (TRL 5)**: Based on experienced gained in PINTA2**,** finish the development of methodologies & tools for virtual validation and/or certification of traction systems, and apply Software in the Loop (SIL) tests as much as possible to cover the complete traction system control and combine with vehicle level TCMS validation. Replace physical tests by virtual proofs and conclude on the cost and time saving due to this major breakthrough.

- **Pre-standardisation**: Based on experience gained in PINTA2**,** continue to perform pre-standardisation tasks for new solutions & new technologies (e.g. new insulation material, sensors network, etc.), complete normative evolution via cooperation with the S2R CCA Working Area "Standardisation" and all needed normative bodies in order to align new solutions emergence with suitable normative environment, allowing a fast introduction on markets for the solutions developed within the S2R JU.

2. Work stream 2: HVAC

The research activities of this call are the continuation of previous activities that have started in S2R-CFM-IP1-01-2019 within the AWP2019. The previous project has covered requirement specification, analysing existing units, simulations, alternative refrigerants, conformity and risk assessment as well as the beginning of the further prototype development and pre-standardisation.

The current call covers the following actions:

- Further development and adoption of existing prototypes of HVACs (with CO_2 refrigerant and integration of a heat pump) incl. carrying out a type test
- Integration of the adopted HVAC-prototypes into the test vehicle(s), installation of measuring equipment and testing within a climatic chamber
- Test of HVAC-prototype in real operation over 12 months incl. comparison with the conventional HVAC unit with respect to behaviour, thermal comfort, energy consumption, maintainability and reliability

- Continuation of the pre-standardisation of interfaces and functions of HVAC subsystems (compressor, heat exchanger etc.) as well as interfaces for vehicle integration of HVACs (energy supply, mechanical dimensions, data exchange, etc.)
- Final report on HVACs with natural gases concerning technical behaviour, technical readiness and maintainability as well as migration strategy and application for new and existing trains

The work will be the continuation of the HVAC-activities of S2R-CFM-IP1-01 -2019 with demonstration of eco-friendly HVACs with natural gases in real operation (TRL 7). The following tasks are foreseen:

- Further development of prototypes
- Test of prototypes (within a climatic chamber and in real operation)
- Pre-standardization of interfaces
- Assessing of alternative refrigerants, risk analysis and migration strategy

3. Work stram 3: Battery and Hydrogen solutions

The focus of this work stream is basic research on rolling stock, infrastructure and operational aspects for retrofitting existing regional trains. Further, preparatory work for next generation BEMUs and HMUs is carried out (TRL 2). Higher TRL levels will be achieved in possible follow-up projects.

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

- Evaluation of use cases for regional trains with respect to train size, non-electrified line length, target costs, market volume, business models, time scale and migration strategy
- Looking at standardised and cost-efficient solutions for infrastructure with respect to battery charging, hydrogen refilling and green hydrogen production
- Looking at operational aspects of the new technologies, e.g. service, maintenance, handling, safety, emergency concept, driver training and time table with recharging slots
- Basic research on rolling stock for retrofitting and next generation BEMU and HMU, mainly on battery as well as weight and energy management. The work on hydrogen storage and fuel cell technology for rail application should be carried out in close cooperation with the FCH Joint Undertaking
- Optimise, accelerate and simplify the authorisation process, especially for retrofitting
- Preparation work for high technical performances and low LCC Technical Demonstrators in subsequent research activities wich could take place in a possible follow up of the S2R JU.

Based on the above mentioned actions, the described call is in line with the three priority R&I topics as mentioned in the 2019 issued Roland Berger H2-study[33] to unlock the full market potential of alternative drives. In particular, an optimised storage system is part of this call and a large-scale demonstration is foreseen to take place in a follow up of S2R.

The proposal should explain how the results on energy storage systems of previous S2R JU projects, such as FFL4E (730823) and OPEUS (730827) are taken into account.

Work Streams results should be placed in the context of the demo plans, which are developed in conjunction with MAAP part B. In addition, the demo plans should be accompanied with integration

[33] https://shift2rail.org/wp-content/uploads/2019/05/Study-on-the-use-of-fuel-cells-and-hydrogen-in-the-railway-environment_final.pdf

and migration plans to implement produced solutions in the rail environment to support and speed up deployment.

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 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-OC-IP1-01-2020
- S2R-CFM-IP1-01-2019
- S2R-CFM-CCA-01-2019
- S2R-CFM-IPX and CCA-02-2020

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

- FR8HUB (GA 777402)
- FR8RAIL-2 (GA 826206)

The action shall actively contribute to the S2R standardisation rolling development plans wherever relevant.

The action shall actively contribute to the S2R KPIs development. This shall lead to publicly available deliverable, quantified indicatively on a semi-annual basis.

The planned activities of the action should take into account the revised MAAP.

The S2R JU will only fund one proposal under this topic.

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.

EXPECTED IMPACT

For traction, the previous PINTA and PINTA2 projects have defined and worked on seven Traction KPIs (capital cost, maintenance cost, energy cost, reliability, noise, weight, volume of traction sub-system) directly linked with S2R KPIs (LCC, reliability, capacity). The long term quantified performance targets have been described.

The most significant quantitative benefits of the present action brought by new technologies, methodologies and simulation tools developed within this action will include the conclusion on Traction KPIs improvements progress toward previously described targets:

- A reduction up to -30% of the traction system validation/certification duration and costs through simplification, harmonization of rules and replacing very expensive "on site" certification tests by more cost efficient simulations and/or static bench tests;
- A reduction up to -20% in maintenance costs, thanks to high reliability and “maintenance oriented design” components and traction sub-system hardware completed by smart maintenance;
- A reduction up to -15% in traction energy consumption thanks to the use of higher energy efficiency technologies, significant weight reduction, and naturally cooled components (instead of using pumps or fans);
- Traction noise reduction up to -10% thanks to the application of methodologies of noise emission prediction, new low noise solutions on traction components;
- Further important impacts are also be expected in the domains of train capacity, passenger comfort, battery or Hydrogen powered trains autonomy extension up to +10% thanks to traction components weight and volume savings;
- Finally, the traction LCC will be reduced thanks to a specific focus – in complement with energy and maintenance - on the reduction of capital cost of the traction systems.

For HVAC, the action will contribute to the market introduction of eco-friendly HVAC systems taking into account the near-term shortage of conventional refrigerants. Additional impacts are:

- Reduction of LCC by reducing energy consumption of about 20-45% by integrating heat pumps and the usage of standardized interfaces
- Standardised control interface for optimisation of vehicle energy management and condition-based maintenance

For Battery and Hydrogen solutions, the action has an impact on CO_2-reduction of railway traffic and is thus in accordance with the ERRAC vision 2050[34] where railway traffic is seen as the sustainable backbone of an intermodal “Mobility as a service” within cities and beyond. If regional diesel trains (with two cars) are substituted by BEMUs or HMUs the CO_2-Impact is reduced by about 4kg/train-km.

Further the action contributes to standardisation and the market introduction of alternative drives to gain a competitive advantage for the European railway industry.

The research and innovation activities results shall be brought in the form of a demonstrator in the context of InnoTrans 2022, including on the S2R JU stand.

The research and innovation activities results shall be shown through the High TRL demonstrators planned to end by the end of 2022.

<u>Type of Action</u>: Innovation Action (IA)

[34] https://errac.org/wp-content/uploads/2019/03/122017_ERRAC-RAIL-2050.pdf

4.1.2 S2R-CFM-IP1-02-2020: Validation of new technologies for the TCMS

SPECIFIC CHALLENGE

The 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).

The above mentioned technologies have been tested in relevant environments in order to ease their validation with a TRL 6/7 in the current action. In parallel, the following activities have been carried out without integrating them in the laboratory demonstrators:

- Specification of new application profiles, i.e. improvement of ATO integration (TRL 4).
- Evolution studies of the IEC 61375-2-6 (TCN train-to-ground standard) for merging the link with the new signalling communication technologies developed within X2RAIL-1 (S2R-CFM-IP2-01-2015) and X2Rail-3 (S2R-CFM-IP2-01-2018) projects (TRL 2/3).
- With the support of the new TCMS technologies, concepts, architectures and interfaces for the Driver Machine Interfaces (DMI), including safety related ones, will be developed and prototyped. A starting point will be the technical report CENELEC TR 50542-1 Railway applications - Driver's cab train display controller (TDC) and the related documents, which should be completed and complemented (TRL 3/4).

In order to progress towards the expected radical change in the TCMS paradigms, the proposed technologies have to be implemented in a relevant environment, so that they could be validated in a later and final stage.

A reference architecture for CCS will be developed in the action to be funded under topic S2R-CFM-IPX-CCA-01-2019. AWP2020 includes the continuation of these activities inside the topic S2R-CFM-IPX and CCA-02-2020. Subsequently, each CFM proposal has to be aligned with the progress in S2R-CFM-IPX-CCA-01-2019 and S2R-CFM-IPX and CCA-02-2020; in particular the system approach and interoperability of solutions must be ensured across S2R IP/CCA activities and for future developments.

SCOPE

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

Research Area	Specific Technological objective	Demonstrator		TRL
Train Control & Monit. System (TCMS)	Wireless TCMS	Metro		6/7
		Regional		6
	Drive-by-data	Metro		6/7
		Regional		6
	Functional distribution Framework	Metro		6/7
		Regional		6
	Functional Open Coupling	Regional		5/6
	Virtual Certification	Generic		5/6
				5/6

To support the demonstration of the technologies of the previous table with the expected TRL, the following tasks are expected to be carried out:

- Extensions to the CONNECTA-2 demonstrator in order to pass from prototypes to TRL 6/7 solutions (work-stream 1).
- To carry out a safety analysis of the new technologies (work-stream 1).
- The definition of test cases which will validate the technologies in urban and regional applications (work-stream 1).
- To carry out testing and reporting under laboratory Virtual Certification Frameworks (work-stream 1).
- Installation studies in order to analyze the changes to be made in the train to incorporate the new technologies (work-stream 1).
- To carry out the tests in depot for the technologies to be validated in field tests (work-stream 2).
- To carry out field tests according to the table above (work-stream 2).
- To mount, test and report the technologies under test (work-stream 2).
- To dismantle the technologies under tests and carry out the re-commissioning of the train units (work-stream 3).

Additionally, further studies and specification on the following fields are expected to be carried out:

- Low-level specification of the Application Profiles for train-level communications, this is over the Functional Open Coupling (work-stream 4).

- Further studies in the Application Profile for ATO GoA3/4 functions together with CFM-IP2-01-2019, continuing the work made by CONNECTA-2 (work-stream 4).
- Additional function definition for the Functional Open Coupling, taking as a reference the UIC 556, e.g. Traction, Braking, Lighting (work-stream 4).
- Extension of the work made by CONNECTA-2 regarding the visualization of Functional Open Coupling functions in DMI, providing the definition of more functions (work-stream 4).
- Specification of additional functions for T2G communications not covered by the IEC 61375-2-6, such as the CCTV (work-stream 4).
- Specification of the full interface based on SIP for the interoperability with the Adaptable Communication System (work-stream 4).
- Benchmarking activity of such activity outcome with regard the current IEC 61375 series and other upcoming standards from different industries (work-stream 4).

Work-streams results should be placed in the context of the demo plans, which are developed in conjunction with MAAP part B. In addition, the demo plans should be accompanied with integration and migration plans to implement produced solutions in the rail environment to support and speed up deployment.

An indicative scheduling of the deliverables is suggested below[35] :

- Deliverable under work-stream 1 is expected by Q4 2021.
- Deliverable under work-stream 2 is expected by month Q2 2022.
- Deliverable under work-stream 3 is expected by the end of the project.
- Deliverable under work-stream 4 is a project-long work-stream and is expected by the end of the project.

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 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-OC-IP1-02-2020
- S2R-CFM-IP2-01-2019
- S2R-CFM-IP5-01-2020
- S2R-CFM-IPX-CCA-01-2019
- S2R-CFM-IPX and CCA-02-2020

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

- CONNECTA-2 (GA 826098)

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

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

The action shall actively contribute to the S2R standardisation rolling development plans wherever relevant.

The action shall actively contribute to the S2R KPIs development. This shall lead to publicly available deliverable, quantified indicatively on a semi-annual basis.

The planned activities of the action should take into account the revised MAAP.

The S2R JU will only fund one proposal under this topic.

EXPECTED IMPACT

The Action will contribute to the implementation in a relevant environment, for regional and urban railway applications, of:

- The Drive-by-Data concept, including the elimination of train lines, the integration of safety-critical functions (like Doors and Bogie Monitoring System) and therefore 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 and its supporting toolbox to enable further reductions in LCC;
- The Wireless Train Backbone and Wireless Consist Network, to reduce LCC, increase operational reliability and capacity, by adding flexibility to the system;
- The Functional Open Coupling to improve capacity, flexibility and to reduce LCC.

All in all, the relative weight of the benefits provided by this work on the overall system-level KPIs for the whole S2R JU 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%).

The research and innovation activities results shall be brought in the form of a demonstrator in the context of InnoTrans 2022, including on the S2R JU stand.

Type of action: Innovation Action (IA)

4.1.3 S2R-CFM-IP2-01-2020 [Completion of activities for Adaptable Communication, Moving Block, Fail safe Train Localisation (including satellite), Zero on site Testing, Formal Methods and Cyber Security]

SPECIFIC CHALLENGE

In the framework of the technological developments foreseen within the Innovation Programme 2 of the S2R Master Plan, the call should focus on the evolution and completion of the activities started in the actions financed in X2RAIL-1 (GA 730640), X2RAIL-2 (GA 777465) and X2RAIL-3 (GA: 826141) related to Communications, Moving Block, Fail safe Train Localisation, Testing Methodologies, Formal Methods and Cyber Security.

New technologies and functionalities need to be incorporated in ERTMS, with the aim of improving the capability of tackling new markets and new railway segments. Localisation (in particular work initiated on satellite) and moving block applications are one of the key aspects in the ERTMS evolution.

Currently, due to the complexity of the signalling systems and the differences between sites and applications, a large amount of tests must be carried out on-site. On-site tests take up a lot of effort in terms of time and cost (about 5 to 10 times the effort compared to similar tests done in the lab). The challenge is to reduce on-site tests for signalling systems, leading to reducing overall testing costs.

Additional challenges arise from integrating new functionalities into the existing ERTMS system in operation (i.e. moving block / train localication). The approval will require additional testing. Today's modern software methodologies shall support automating this testing on one side and in addition transferring this test to the lab.

The actions aim to consolidate and bring to conclusion, through development and testing of prototypes, the outcomes and results coming from the previous grants in order to achieving the ambitious objectives planned in the Master Plan and in the MAAP.

Considering the AWP2019 including the new S2R-CFM-IPX-CCA-01-2019 topic, a reference architecture for CCS is expected to be developed. Furthermore the AWP2020 includes the continuation of this in the S2R-CFM-IPX and CCA-02-2020 topic. The S2R JU Members will verify in this call the impact, the developments in the action to be funded under S2R-CFM-IPX-CCA-01-2019 and S2R-CFM-IPX and CCA-02-2020 have or potentially have on the content of each work streams activities. Subsequently each CFM proposal has to be aligned, as far as possible, against the latest progress in S2R-CFM-IPX-CCA-01-2019 and S2R-CFM-IPX and CCA-02-2020; in particular the system approach and interoperability of solutions must be ensured across S2R IP/CCA activities and for future developments.

SCOPE

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

TD2.1 – Adaptable Communication for all Railways: In line with the field test strategy created in X2Rail-3 and the work performed in the new S2R-CFM-IPX-CCA-01-2019 and S2R-CFM-IPX and CCA-02-2020 activities, the action to be funded under this topic will work on a detailed field test plan and bring the adaptable communication system demonstrators into one or two field trials, which represent realistic and live rail environments. Based on the findings gathered from X2Rail-3 combined with the results from the field trials to be performed in this action, the activities will conclude in an update and refinement, if necessary correction, of the adaptable communication system specifications. Based on the evolution and maturity of other

technologies the action will also aim to investigate potential integration of different technology demonstrators and validate the functionality from a system perspective.
Furthermore and depending on the outcome of the antenna subsystem specification (developed in X2Rail-3) it might become advisable to extend the analysis work and focus on specific aspects within the rail environment.

In this framework, the activities are expected to cover the following points:

a. Create a field test plan for the demonstrator validation activities;
b. Install and integrate demonstrators at one or two the field sites;
c. Perform field test activities and validate the capabilities of the Adaptable Communication System in line with the field test plan;
d. Collect and analyse results from the field testing activities and update relevant Adaptable Communication System documents, including system specification.

The action is expected to reach TRL 6/7.

- **TD2.3 - Moving Block**: the scope of the action is to create site tests of different Moving Block systems, in collaboration with the Infrastructure Managers. These tests will be based on the system specification work carried out within X2Rail-1, X2Rail-3, and the laboratory prototypes to be developed within X2Rail-3. In addition, the scope will also include: :
  - updating of the Moving Block specifications (developed in X2Rail-1 X2Rail-3 and the outcomes of the new S2R-CFM-IPX-CCA-01-2019 and S2R-CFM-IPX and CCA-02-2020 activities);
  - further examination of candidate future moving block architectures, which are to be determined within X2Rail-3.

In this framework, the activities are expected to cover the following points:

a. Creation of Site Based Moving Block Technical Demonstrators in collaboration with Infrastructure Managers.
Ideally, these would be in collaboration with other TDs, for example Communications, Train Location, Train Integrity, Traffic Management, ATO. It is unlikely that any one TD will include all these different TDs;
b. Work to maintain the results from X2Rail-3 for Operational and Engineering Rules, and for System Specifications, based on feedback from the TDs. This work should be carried out in collaboration with the work in the corresponding Open Call "S2R-OC-IP2-01-2020" to create semi-formal or formal models Moving Block system;
c. Examine most promising ideas for future Moving Block architectures, based on the work to be performed within X2Rail-3 on this topic. This shall be done in collaboration with other TDs, for example Communications, Train Location, Train Integrity.

The action is expected to reach TRL 6/7.

- **TD2.4 – Fail safe train positioning (including satellite)**: the aim of the action is to bring to conclusion the activities started in the previous projects (X2Rail-2 and the outcomes of the new S2R-CFM-IPX-CCA-01-2019 and S2R-CFM-IPX and CCA-02-2020 activities) and to provide demonstrators that will be tested in laboratories and on site. The action will also finalise the Cost Benefits Analysis based on the Field Tests and will cooperate with IMs and RUs to define the Migration Strategy for the introduction of the TD 2.4 Fail Safe Train Positioning into both existing and new ERTMS solutions.

In this framework, activities are expected to cover the following points regarding preparation of prototypes:

a. Completion of the developments based on the Virtual Balise (VB) concept and on the combined use of different technologies such as, for example, IMU, EGNSS, Digital Map, kinematics sensors to compute a safe train position;
b. Completion of the Functional and Not Functional Laboratory and Field Test Specifications;
c. Completion of the definition of the GNSS Service Provision required for TD 2.4;
d. Completion of the definition of the new Verification & Validation (V&V) process suitable for also covering the aspects related to the introduction of the new technologies and the GNSS Service Provision;
e. Definition of the KPIs suitable for evaluating the Reliability and Maintainability System (RAMS) indexes associated with the introduction of the new technologies and their integrations as components of the ERTMS Interoperable Constituents;
f. Verification in the Laboratories of the developed components of the new Fail-Safe Train Positioning; The laboratory verification test infrastructure shall also be based on the results of the cooperation with TD 2.6 (Zero-On-Site Testing);
g. Support the integration of the developed components with the complete Fail-Safe Train Positioning prototypes and their verification in the Laboratories in accordance with the above defined Functional and Not Functional Laboratory and Field Test Specifications; if necessary, update of some technologies based on the technology trend and results available in the project timeframe;
h. Contribute to the upgrade of the Railways Minimum Operational Performance Standards based on the Laboratory and Field Tests as well as the retrofits coming from the GNSS Stakeholders.

In addition, the action to be funded under this topic is expected to cover the following activities regarding field testing:

a. Installation and commissioning of three demonstrators based on the new Fail-Safe Train Positioning on different Laboratories and on Pilot Trial Sites, representative of different railways application domains such as low traffic lines, regional lines, and high speed lines;
b. Field test campaigns based on the current CENELEC standards, the new defined V&V Process; if available and possible, the use of the TD 2.1 radio communication infrastructure to exploit and quantitatively assess the benefits coming from a high performance network shall also be performed;
c. Acquisition and recording of Field Diagnostic and Measurement Data to populate the TD 2.4 Repository; these filed data shall be used for computing the statistics required for tuning some algorithms, the corrective factors of some key confidence intervals, and the Error Budget Models in the multi-sensor chains;
d. Update of the required Project deliverables (e.g. SRS, System Architecture, Functional Hazard Analysis) to take into account the results of the Lab and Field Test campaigns;
e. Upgrade the definition of the suggestions for enhancing the current ERTMS specifications for the introduction of the new Fail-Safe Train Positioning subsystem, also beyond the concept of virtual balise;
f. Upgrade of the Cost Benefits Analysis based on the Field Tests;
g. Cooperation with IMs and RUs to define the Migration Strategy for the introduction of the TD 2.4 Fail Safe Train Positioning into both existing and new CCS implementation (including ERTMS solutions).

Up to three demonstrators shall be developed. At least one demonstrator shall be a complete SIL 4 system prototype of the Fail-Safe Train Positioning subsystem integrated with an ERTMS based solution, tested in field. In addition, as TD 2.4 also includes some investigations about the use of new sensor technologies (e.g. Inertial Measurement Unit (IMU), kinematics sensors) for improving the

ERTMS Odometry accuracy performance, the use of these new technologies shall developed and verified as TRL 4.

- **TD2.6 – Zero on site testing**: the main focus is the continuation of the activities which have been started with X2Rail-1, X2RAIL-3 as well as based on the outcomes of the new S2R-CFM-IPX-CCA-01-2019 and S2R-CFM-IPX and CCA-02-2020 activities. In addition the integration of results of the other TDs achieved so far is expected to be integrated. A specific emphasis will be the integration of the new technologies provided to support the digitalization of the railway as well as supporting the necessity of interoperability and interconnectivity.

In this framework, activities are expected to cover the following points:

a. The main focus of the activities in Zero on Site Testing (TD2.6) is the continuation of the activities which have been started in X2Rail-1 (WP6) and X2Rail-3 (WP5). In addition the integration of results of the other TDs achieved so far is expected to be integrated. A specific emphasis will be the integration of the new technologies provided to support the digitalization of the railway as well as supporting the necessity of interoperability and interconnectivity;
b. The activities in this phase of the project will be concentrated on the integration of the achieved results as well as the alignment with the challenges that have been identified during prototyping of the future technologies to ensure that the migration will be achieved;
c. The provided prototypes will be further upgraded with missing features of new technologies as well as by integrating the achievements from achievements obtained in the TD (with a focus on links to the ERTMS Game Changers);
d. Both the test and simulation environment as well as the test cases and evaluation need to be considered.

The action is expected to reach TRL 6.

- **TD2.7** – **Formal Methods**: The main objective is to pivot from TD2.7 focus (within X2Rail-2) on formal methods and standard interfaces for the sub-system (component) level, to a signalling system reference architecture based on a 'system of systems' concept using a conceptual (or canonical) data model as basis for data exchange between components. The objective is to establish a demonstrator, connected to the activities to be performed in the action to be funded under the topic S2R-CFM-IPX-CCA-01-2019 and S2R-CFM-IPX and CCA-02-2020 (on system architecture) and/or other TDs, and to define a "guidebook" for the use of Formal Methods to enable increased efficiency, automation and use of standards. The demonstrator and guidebook will take into account the results stemmingfrom X2Rail-2, and support a business case study of the impact and use of formal methods to achieve lowered LCC for the modular signalling system reference architecture.

In this framework, activities are expected to cover the following points:

Development of a guidebook covering methodology and processes for:

a. Specification, validation, verification and maintenance (modification) of a signalling system reference architecture, its components, interfaces and requirements;
b. Independent implementation and maintenance of components (automated data preparation for engineering and verification);
c. Managing different aspects of generality, e.g. open standards, not tied to a specific implementation, how to use specific standard interfaces.

The demonstrator will be based on a representative selection of a suitable reference architecture stemming from the action S2R-CFM-IPX-CCA-01-2019 and S2R-CFM-IPX and CCA-02-2020, to demonstrate process, methods and approaches for cost-efficient use of formal and semi-formal methods.

The action is expected to reach TRL 4.

- **TD2.11** – **Cyber Security**: The aim of the action is to demonstrate, validate and apply to other demonstrators the holistic cyber-security approaches defined in the previous X2Rail-1 and X2Rail-3 projects.

In this framework,the activities are expected to cover the following points:

a. Demonstrate and validate the exhaustive approach for railway cyber security defined during the previous projects X2RAIL-1,X2RAIL-3 as well as based on the outcomes of the new S2R-CFM-IPX-CCA-01-2019 and S2R-CFM-IPX and CCA-02-2020 activities.
   The TD2.11 will apply the risk assessment, control identification, test and validation processes defined during the X2RAIL-1 and X2RAIL-3 projects to the TD2.1 "Adaptable communication".

   Based on the detailed application of the cyber security process to the technical demonstrator TD 2.1, a return of experience of the S2R cyber security approach will be performed. This should allow to validate it and to propose further improvements or processes (TRL 5/6).

b. Support for cyber-secure architecture definition for other technical demonstrators.
   Using the cyber security processes defined in project X2RAIL-1 and X2RAIL-3, the TD2.11 should analyse and propose, or validate, cyber-secure architectures and cyber security requirements for other technical demonstrators in order to ensure that the proposed solution compliant with the best cyber security practices (TRL 3).

c. Detailed step-by-step guideline for cyber security implementation.
   Due to the complexity of the cybersecurity subject for huge system and to the complexity of the rail sector organisation, the scope of the current task is to write a step-by-step guideline on how to implement cyber security for the railway sector considering all the stakeholders (operators, integrators, product suppliers and service providers) and the complete railway life-cycle (TRL 3).

d. Implementation of Computer security Incident Response Team (CSIRT) prototype.
   After the study of feasibility of the railway CSIRT in X2Rail-3, the S2R JU members will have to work closely together to set up a common understanding, including a common "ontology", and to set up a working CSIRT environment dedicated to the railway sector.

   Following tasks shall be fulfilled:

   - provide support and needed information to define the CSIRT model;
   - participate to the identification of information sources, to the capture of network architecture and to the analysis of the sub-system dependencies;
   - review and validate the CSIRT environment prototype;
   - provide internal CSIRT expertise to set up a distributed environment and leverage the specific expertise from all parties.

This specification and prototype implementation of the R-CSIRT will be supported by an Open Call addressing CERT[36]/CSIRT design and implementation (action to be funded under S2R-OC-IP2-01-2019) (TRL 4).

Work-streams results should be placed in the context of the demo plans, which are developed in conjunction with MAAP part B. In addition, the demo plans should be accompanied with integration and migration plans to implement produced solutions in the rail environment to support and speed up deployment.

In addition to the above-mentioned work streams, system demonstrations will support the validation and will foster deployment of the additional functions developed by the programme. Several TDs will be combined into ITDs (Integrated Technology Demonstrators). Network of test sites and test trains will facilitate these demonstrations. A specific project activity shall target this objective.

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 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.

Most of the activities of this work area will need to set up a collaboration with ERA in order to evaluate the potential impacts of the work streams on the current ERTMS specification baseline and TSI.

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: Validation of new technologies for the TCMS
- S2R-OC-IP2-01-2020: Modelling of the Moving Block system specification and future architecture Receiver Autonomous Integrity Monitoring (RAIM) algorithms, Assessment Report and support for Railway Minimum Operational Performance Standards.
- S2R-OC-IP2-02-2020: Study on alternative bearers and on communication protocols.
- S2R-CFM-IP5-01-2020: Use-centric rail freight innovation for Single European Railway Area
- S2R-CFM-IPX-CCA-01-2019: S2R System Architecture and Conceptual Data Model
- S2R-CFM-IP2-01-2019: Completion of activities for Adaptable Communication, Moving Block, Fail safe Train Localisation (including satellite), Zero on site Testing, Formal Methods and Cyber Security
  S2R-CFM-IPX and CCA-02-2020: Evolution of Railways System Architecture and Conceptual Data Model (CDM)

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

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- X2RAIL-3 (GA 826141)
- CONNECTA-2 (GA 826098)

The action shall actively contribute to the S2R standardisation rolling development plans wherever relevant.

[36] CERT: Computer Emergency Response Team

The action shall actively contribute to the S2R KPIs development. This shall lead to publicly available deliverable, quantified indicatively on a semi-annual basis.

The planned activities of the action should take into account the revised MAAP.

The S2R JU will only fund one proposal under this topic.

EXPECTED IMPACT

The actions are expected to contribute to:

- LCC reduction (through sharing of the communication network and possibility using public network);
- Additional service performance and support of capacity increase where the performances of the currently-deployed telecom system is creating a bottleneck;
- Demonstrate the possibility to integrate a number of heterogeneous radio access technologies and communication networks into one solution, showing how the concept of radio bearer independency allows a smooth and low cost migration between successive generations of radio technologies, and can be completely transparent for the signalling application within the different railways segments;
- Additional confidence in the operation of Moving Block systems in a railway context (TD2.3), resulting from on-site technical demonstrators of Moving Block;
- Achieve more rigorous specifications of Moving Block signalling (TD2.3) based on collaboration with the corresponding Open Call "S2R-OC-IP2-01-2020" to create formal or semi-formal specifications. This would also allow to refine documentation of potential future enhancements of Moving Block systems;
- Increased capacity, depending on railway type, through the application of Moving Block signalling (TD2.3). The IMPACT and IMPACT2 projects have identified a possible contribution from IP2 as a whole of up to 50% increase in capacity on high speed and freight railways, compared with benchmark base cases;
- The new technology based on GNSS and fail-safe train positioning system (TD2.4) should allow increasing opportunities of application of ERTMS to new railway segments e.g. to low traffic regional and freight lines that are placed in rural areas, where the reduction of installation (CAPEX) and maintenance costs (OPEX) is one of the most significant key aspects;
- The enhanced test environment (TD2.6) will contribute to operational efficiency. Further there will be a reduction in effort spent and time consumed for overall system testing as well as up test for upgrades of the system. Installation cycles will be optimized decreasing the impact on operation while upgrading the system. Moreover a positive impact on the amount of test equipment is expected due to modern technologies like virtualization and connection of existing labs
- The action related to the TD2.7 will contribute to:
    - LCC reduction:
        - Higher efficiency in supply and approval of signalling systems in general, and possibly specifically so for signalling system components part of the work to be performed in the action to be funded under topic;
        - Increasing reuse of requirements and architectures;
        - Reduce effort spent and time consumed for (system) testing;
        - Increase efficiency to introduce new functionality into the overall signalling system;
        - Signalling systems supporting modularity and plug-and-play.
    - Wider adaptation and use of Formal Methods and new technology:

        - Collaboration possibly with on-going IPX CFM and/or other TDs, e.g. on common demo environment(s);
        - "Handbook" for the use of Formal Methods to enable wider adaptations to increase efficiency, automation and use of standards.
- Regarding the cyber security, the potential impacts are:
    - Common up-to-date Cyber Security approach for railway systems, including common security and impact assessments, threat landscape and security-by-design guidelines;
    - LCC reduction through the definition and the sharing of the best cyber security processes, architecture and practice. Due to the shorter life cycle of cyber security solutions compared to railway product, the cybersecurity could have significant cost impact during the operational and maintenance phase. A proper approach of cyber security implementation that helps patch management and reduces the attack surface is important for reduction of LCC;
    - Increase operational efficiency by reducing the risk of unavailability due to cyber security issues;
    - Increase the incident response capacity of the railway sector through prototype of collaboration tool to tackle cyber security issue inside an organisation or between organisations.

The Impact expected from the project activities shall be quantified for each of the items above in relation to the S2R KPI model by the awared project as well as against the S2R JU Regulation's KPIs.

The research and innovation activities results shall be brought in the form of a demonstrator in the context of InnoTrans 2022, including on the S2R JU stand.

Type of Action: Innovation Action (IA)

4.1.4 S2R-CFM-IP3-01-2020: Research into optimised and future railway infrastructure

SPECIFIC CHALLENGE

The European railway industry faces the huge challenge of needing increased network capacity as the result of higher customer demands. This is compounded by ageing infrastructure assets that require efficient and sustainable interventions to maintain and improve current levels of performance. To meet these demands and increase the operational performance of critical railway infrastructure assets, innovation must be delivered to enable a step-change in reliability, availability, maintainability and safety (RAMS) whilst also optimising asset capital and LCC. The overall specific challenge is to develop technology and technology demonstrators for the track, switches and crossings (S&C), bridge and tunnel assets. The challenges are divided into: enhancements to existing track, switches and crossings; next generation track, switches and crossings; and enhanced performance of tunnel and bridges.

A reference architecture for CCS will be developed in the action to be funded under topic S2R-CFM-IPX-CCA-01-2019. AWP2020 includes the continuation of these activities inside the topic S2R-CFM-IPX and CCA-02-2020. Subsequently, each CFM proposal has to be aligned with the progress in S2R-CFM-IPX-CCA-01-2019 and S2R-CFM-IPX and CCA-02-2020; in particular the system approach and interoperability of solutions must be ensured across S2R IP/CCA activities and for future developments.

Enhancing existing track, S&C :

The challenge for the existing track, S&C system is to get more availably capacity on lines by reducing operational failures that cause delays and disruptions. This can be achieved via increase of the reliability by improved performance of components, and the availability by improved maintenance. A Reduction of LCC for track, switches and crossings with maintained safety is also an important challenge.

Next generation track, S&C:

The overall specific challenge is to develop technology and integrated technology demonstrators for track, switches and crossings, targeting a time horizon of around forty years beyond current state-of-the-art. Therefore, harmonisation toward today's railway system is less important, although retention of key railway functionality is required, in order to maintain compatibility with existing systems. Next generation solutions will implement technologies capable of providing a step-change in RAMS performance improvement, with a significant reduction in life cycle costs.

Enhanced performance of tunnel and bridges:

For sustainable and economical management of tunnel and bridges, these assets will require extended service life, and with less disruption to service compared to current situation with maintained or improved safety. Enhanced inspection methods should record early signals of deterioration and in combination with efficient interventions allow for actions with improved results, at lower cost and less traffic disturbances compared to current practice.

SCOPE

The proposed research should address all the different aspects of enhancing existing systems; finding solutions for future track, switches and crossings, and bridges and tunnels below; in line with the S2R MAAP regarding TD3.1, TD3.2, TD3.3, TD3.4, and TD3.5. The actions should build upon and are dependent on successful outputs from previous and existing S2R IP3 projects towards achieving the overall S2R JU objectives.

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

Work-stream 1: enhancing existing track, S&C:

a) Refine the understanding of the entire track system and its components including wheel and rail interaction. Explore environmental footprints and promote sustainable solutions. Increase reliability of track system and perform demonstrators up to TRL 7.
b) Develop hybrid testing and other simulations for validation and certification, and merge with developed laboratory and field results, up to equivalent of TRL 7.
c) Enhanced understanding and optimisation of monitoring and maintenance activities such as tamping and grinding to enhance the performance of the railway system up to TRL 7.
d) Validation and in-track full assessment, including LCC analysis, of developed demonstrator of enhanced S&C systems with improved RAMS. Establish the specifications of S&C systems with fewer and more reliable components as well as easier integration and commissioning procedures, reaching up to TRL 7.
e) Assessment and development of sensor systems and component prediction, monitoring and maintenance strategies, based on existing predictive tools, to improve LCC and increase availability of the S&C systems reaching TRL 7.
f) Analysis and evaluation of the data gathering methods in the developed S&C systems and sub-systems to support digitalisation, reaching TRL 7.

Work-stream 2: next generation track, S&C:

a) Next generation track and S&C whole system solutions will minimise environmental impact and carbon footprint, ensure low levels of noise and vibration and improve system resilience against climate change, up to equivalent of TRL 6.
b) Development of next generation track and S&C sub-structure solutions, including consideration for required transition zones. Feasible component and sub-system innovation are to be demonstrated, both physically and virtually, through whole system integration, reaching TRL 6.
c) Development of innovative and autonomous track and S&C inspection, maintenance and repair techniques, with integrated monitoring, analysis and predictive capability, reaching TRL 6.
d) Demonstration of S&C control, monitoring and sensing systems that enable fault tolerant control with self-diagnostics and maintenance, reaching up to TRL 6.
e) Development of fail-safe S&C kinematic systems with embedded functional redundancy and self-inspection / self-adjustment capabilities. Prototypes will be validated, via simulation and physical testing, up to TRL 6.
f) Demonstration of next generation track and S&C components, utilising advanced design, materials and manufacturing techniques. The demonstration is to be in a relevant operational railway environment, to confirm RAMS performance prior to integration within a whole system concept, reaching TRL 6.
g) Development of full-scale, whole system demonstrators (including drainage) for next generation track and S&C solutions, using advanced design, materials, manufacturing, construction and installation techniques, reaching up to TRL 6.

Work-stream 3: enhanced performance of tunnel and bridges:

a) Tunnel health monitoring covering both monitoring of tunnel drainage clogging and on-board sensor systems for health monitoring of tunnel integrity, when relevant at speed of approx. 20km/h at TRL 7.
b) Tunnel improvement covering, restoration of tunnel drainage, and replacement of damaged lining, with reduced traffic disturbances and improved working environment expected to reach TRL 6/7.

c) Bridge health monitoring covering both optical monitoring methods for geometry and digitalization, and enhanced fatigue capability utilization, reaching TRL 7.
d) Improvement of bridge service capability covering improved bearing capacity and fatigue capacity of railway bridges with focus not to disturb traffic during installation, reaching up to TRL 7.
e) Develop technology to reduce cost of bridges for bridges high speed traffic covering damping and resonance under rapid cyclic loading, passive dampers to improve bridge damping and proposal for improved design philosophy, reaching equivalent to TRL 7.

Work Streams results should be placed in the context of the demo plans, which are developed in conjunction with MAAP part B. In addition, the demo plans should be accompanied with integration and migration plans to implement produced solutions in the rail environment to support and speed up deployment.

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 S2R AWP for 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 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-IPX-CCA-01-2019: S2R System Architecture and Conceptual Data Model
- S2R-OC-IP3-01-2020: Next Generation Track Transition Zones
  S2R-CFM-IPX and CCA-02-2020: Evolution of Railways System Architecture and Conceptual Data Model (CDM)

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

- IN2TRACK-2 (GA 826255)

The action shall actively contribute to the S2R standardisation rolling development plans wherever relevant.

The action shall actively contribute to the S2R KPIs development. This shall lead to publicly available deliverables, quantified indicatively on a semi-annual basis.

The planned activities of the action should take into account the revised MAAP.

The S2R JU will only fund one proposal under this topic.

EXPECTED IMPACT

Innovative technology will be demonstrated, which will enable a change in construction and operation of railway infrastructure compared to present practised methods. With successful prototypes, capacity and reliability should increase together with reduction of costs for railway transport. Substantial contribution consists of:

- Provide enhanced operational availability by up to 20% of infrastructure by reducing service-affecting failures through more robust and reliable products, procedures and processes.
- Decreased installation, maintenance and replacement costs by 10% due to reduced complexity, modular and installation-friendly solutions.
- Provide an extended operational life by 30%, with decreased maintenance requirements through enhanced infrastructure asset solutions leading to improved LCC.
- Lower life costs by enabling predictive and proactive maintenance interventions, including enhanced condition monitoring and automation, to avoid excessive asset degradation.
- Significantly improvement in reliability, availability maintainability and safety performance for the life of next generation track, S&C.
- Extend economical service life of tunnels by more than 10 years by enhanced inspection and maintenance methods allowing more uptime and improved safety.
- Enhance bridge bearing capacity and improving bridge dynamics to allow up to 50% increase of line speeds.
- Proposal to more refined codes on bridge dynamics allowing for less expensive special solutions on high speed lines leading to up to 25 % cost savings of bridges.
- Increased attractiveness for end users through increase in operational reliability, fewer service disruptions and reduced costs.
- Reduced time to market due to early validation of innovative technologies through virtual and hybrid testing methodologies.
- Enhanced customer experience through better ride comfort resulting from better maintained and higher performing infrastructure assets.
- Improved competitiveness and public acceptance through enhanced green credentials, reduced noise and vibration and improved sustainability.
- Reduced environmental impact of track components.

The research and innovation activities results shall be brought in the form of a demonstrator in the context of InnoTrans 2022, including on the S2R JU stand.

Type of Action: Innovation Action (IA)

4.1.5 S2R-CFM-IP4-01-2020: Enhanced end-user centric travel ecosystem

SPECIFIC CHALLENGE

The topic addresses the three IP4 R&I areas described in the S2R Master Plan: the "Multimodal Travel Services" (TD4.2 and TD4.3), the "Customer Experience Applications" (TD4.4 and TD4.5) and the "Technical Framework" (TD4.1 and TD4.6). Previous research activities have been conducted on co-modal journeys using the main transport modes such as airways, railways, coach and public transport, with the related business rules, and more recently on the MaaS ecosystem with an inter-modal approach to the urban environment including also personal and shared transport modes. The 'co-modality risk' (i.e. that a pre-purchased co-modal trip risks to leave a passenger stranded or non-reimbursed if a connection is missed due to service-disruption) highlights the challenge to ensure accommodation of trips that guarantee (despite service disruptions) 'end-to-end' travel. The challenge in this case is ensure technical enablement of those business models in the market which eliminate that risk and which are characterized by Inter-TSP agreements covering 'Interline' (single mode) and 'Intermodal' (multiple mode) itineraries.

The current action needs to complete the previous developments and fill the gaps related to intermodality, with a set of specifications and reference implementation reaching TRL 7. More specifically, the action must answer the following challenges:

- Prepare the S2R IP4 ecosystem for large-scale implementation, taking into consideration technical, users and business needs and requirements, such as scalability, coexistence and seamless interaction of multiple ecosystems. Complement the activities already started in previous projects with respect to intermodal travels.
- Prepare the S2R IP4 ecosystem for implementation with current retailer market (whether Travel Service Provider (TSP) retail operation or third party e.g. travel agency) by developing an interface to Travel Companion functions and services enabling the linkage of sales transactions to valid legal and TSP-licensed retail entities;
- Attract TSPs to join the ecosystem, especially small ones, by:
    - Offering a range of functionalities and services integrated in the ecosystem to be consumed by them through a common interface "as a service".
    - Ensuring TSPs are protected from unauthorized access/sales by having the current multimodal travel services accommodate IP4 business rules on current sales licenses, distribution agreements, interline ticketing agreements and potential intermodal ticketing agreements.
- Enhance traveller experience, improving the travel services offered and their access to the ecosystem. Enhance communication channels and exploitation of information among travellers, and among them and travel experts, taking advantage of collaborative approaches.
- Tighten links with other IPs and CCA (especially IP2, IP3 and IPX) to facilitate information flow among IP4 services and other railway systems, allowing the creation of enhanced services for users and operators, following the Conceptual Data Model approach and System Architecture defined by the S2R JU Programme.

A reference architecture for CCS will be developed in the action to be funded under topic S2R-CFM-IPX-CCA-01-2019. AWP2020 includes the continuation of these activities inside the topic S2R-CFM-IPX and CCA-02-2020. Subsequently, each CFM proposal has to be aligned with the progress in S2R-CFM-IPX-CCA-01-2019 and S2R-CFM-IPX and CCA-02-2020; in particular the system approach and interoperability of solutions must be ensured across S2R IP/CCA activities and for future developments.

SCOPE

The proposal must cover all IP4 TDs with the lessons learnt of the on-going projects, filling potential gaps, and making the link when possible with other Innovation Programmes and Cross Cutting Activities.

In order to address the above mentioned challenges, proposals should address all tasks described below, in line with the S2R MAAP:

- Complete deployments and consolidate the interfaces between the Travel Shopping, Booking & Ticketing, Trip-Tracker and Travel Companion components. Enhance seamless travel, user experience and engagement in the ecosystem for all type of users:
    - Provide capabilities for sharing data for users and Travel Service Providers (TSPs) to improve the traveller experience: Collaborative spaces for users (info, feedback) and Information at travel time (congestion, wagon crowded).
    - Make the traveller experience more adaptive to the new technologies using Augmented Reality and Virtual Assistant by improving the authoring and orchestration tool.
    - Enhance user experience, making all the processes, specially ticketing, as seamless as possible, reducing interaction among travelers and the infrastructure.

- Beside big and medium Public Transport Operators (PTOs), a lot of small PTOs (e.g. local bus service providers, taxi companies or car and bike sharing providers) are part of the transport market. These small PTOs often don't have their own customer oriented software system (e.g. journey planner, ticketing or validation system). In order to create a seamless door-to-door travel experience, these PTOs, as feeders and fetchers for the rail, need to be integrated into the European wide travels ecosystem. Therefore a micro-TSP solution as Software as a Service (SaaS) including Journey Planning, Offer Building, Booking, Issuing, Ticketing, Clearing and After Sales services, as well as real time information handling, needs to be developed and integrated.

- Exploit the application of Artificial Intelligence (AI) advances to improve travellers experience and operators performance, specially through the application of Business Analytics techniques (for example, Intelligent assistant to help operators / travellers in their operations, mix of machine learning and business modelling for better decision support, AI methods with data).

- Complete the integration of the different IP4 TDs as part of iTD4.7 - Integrated Technology Demonstrator. Cover the integration/demo in 2022 (real life demo) with additional corridors. Investigate exploitation strategies, market uptake and analysis of addressable Business Models associated to the future application of the IP4 ecosystem, including technical questions like how can multiple ecosystems (Travel Companion Application, Orchestrator and/or the Interoperability Framework) interact as well as business questions like roaming.

- Develop integration of IP4 with the other IPs (linkage with IP3 stations, IP2 TMS and CCA I2M, freight ontologies, following IPX guidelines). With IP3, for example, business analytics for a better management of stations, for improving interaction in a Building Information modelling (BIM) context.

- Integrate all valid and relevant outcomes from IP4 Open Calls projects results within the IP4 ecosystem.

Moreover, activities have to be conducted to guarantee that all developments are sustainable, and specifically embrace software engineering aspects, with a complete set of documents, covering all IP4 developments and all steps, related to specification, design, development, integration and validation.

The action is expected to reach TRL 7.

Work-streams results should be placed in the context of the demo plans, which are developed in conjunction with MAAP part B. In addition, the demo plans should be accompanied with integration and migration plans to implement produced solutions in the rail environment to support and speed up deployment.

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 S2R AWP for 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 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-OC-IP4-01-2020
- S2R-CFM-IPX-CCA-01-2019
- S2R-CFM-IPX and CCA-02-2020

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

- MaaSive (GA 826385)
- CONNECTIVE (GA 777522)
- COHESIVE (GA 777599)

The action shall actively contribute to the S2R standardisation rolling development plans wherever relevant. Additionally, direct contribution and alignment with IPX Programme is required.

The action shall actively contribute to the S2R KPIs development. This shall lead to publicly available deliverable, quantified indicatively on a semi-annual basis.

The planned activities of the action should take into account the revised MAAP.

The S2R JU will only fund one proposal under this topic.

EXPECTED IMPACT

The general objective of IP4 is to simplify the development of mobility ecosystems, giving to the end-users a seamless multi-modal mobility experience, and gathering various TSPs using heterogeneous legacy systems. This project will deliver the following specific impacts:

- Increase the transport attractiveness by providing a seamless set of solutions for door-to-door journey, used for MaaS deployment, or in a broader context including air transport mode.
- Ensure that IP4 accommodates the current marketplace by catering for 100% of the major existing business models : comodality, interline, intermodality, and virtual intermodality.
- Allow at least 3 different types of small PTOs (e.g. small taxi companies, buses like school-bus companies, hotel shuttle services) to access the IP4 ecosystem by collaboration with S2R-OC-IP4-01-2020 thanks to a micro-TSP suite delivered as a service (SaaS).
- Allow MaaS operators to access the IP4 ecosystem and provide the functionality for the MaaS operators participanting in the demonstration.
- Increase the satisfaction of the users by providing TSPs real time information when available.
- Exploit the application of Artificial Intelligent advances to improve travellers experience and operators performance.
- Through data sharing and communication between users, address first- and last-mile issues.
- Raise number of passengers using rail and public transport, while trying to regulate the flow and the rate of traffic according to day's schedules and the needs of users.
- Make the demonstration more attractive, paving the way to a market uptake.
- Develop the technology and scalability of the IP4 ecosystem that allows the different demonstrations within COHESIVE, CONNECTIVE and S2R-OC-IP4-01-2020.
- Provide the implementation of Building Blocks that will support at least two demonstrations (e.g. TRA2022 and Innotrans 2022).

The research and innovation activities results shall be brought in the form of a demonstrator in the context of InnoTrans 2022, including on the S2R JU stand.

Type of Action: Innovation Action (IA)

4.1.6 S2R-CFM-IP5-01-2020: Use-centric rail freight innovation for Single European Railway Area

SPECIFIC CHALLENGE:

Within the challenges highlighted in the IP5 part of the S2R Master Plan, the following specific challenges should be addressed by the proposal in answer to this topic:

1. **Condition based maintenance (CBM)**: Rail operators are facing an increasing complexity of influencing factors on their competitiveness. The required flexibility and agility for adaption can only be granted, if digital technologies are used globally – which is today often not the case. Condition Based and Predictive Maintenance need to transform from a support function of rail freight and asset operation to a source of innovation.
   In the future, CBM plays a key role in identifying additional revenue and profitability potentials using current freight locomotives and wagons. Nowadays each European country is using its own maintenance rulebook with individual thresholds which indicates required maintenance activities. This will affect the roll-out of the defined condition monitoring thresholds tremendously. CBM use cases need to be defined for rail freight, resulting in user-centric specification and design of CBM dashboards with the objective of being used all over Europe with their individual specifications. In this manner, CBM use cases would be aligned with the European rail traffics. The challenge is to create an advanced monitoring solution of locomotive and wagon components to monitor the conditions in different rolling stock types across Europe in a centralised way. Central collection of performance metrics for development of digital maintenance rules is essential.
2. **Smart Freight Wagon Concepts** In order to meet the key challenges in rail freight, it is important that the innovations brought forward are affordable, cost effective and have a quick market uptake. The challenge is to demonstrate these innovations using as basis earlier developed in IP5 research projects and to put forward the foreseen innovations:
   a. **Wagon concepts**: new wagon concepts that will contribute to increased reliability of the freight transport while increasing the payload per meter of train and therefore they will bring the desired development to different rail freight market segments:
      i. Core Market Wagon: demonstration activities with the innovative wagon for the rail freight core markets, following its-5L-wagon design, are required in order to prove the benefits and accelerate the rail freight market-uptake. By putting the enhanced design of the Core-Market Wagon in the context of connected asset with operationally relevant and affordable add-ons, e.g. Wagon On-board (WoBu) Units the challenge of fast practical deployment of a number of IP5 technologies can be mastered. The core market wagon should provide mechanical & digital Interfaces for future solutions such as automatic couplers to enable modular and scalable system. The integration of new braking technologies shall allow higher speeds and load per axle at same or better safe performances.
      ii. **Extended Market Wagon (EMW)**: demonstration activities shall follow the final specification of the wagon structure/ equipment, and the integration of mechanical and electrical components in the novel wagon design, designed for extended rail freight markets. The main challenge in this area is related to the structural integrity of the wagon and the safety of its technical equipment, especially for the supervision of the Extended Market Wagon. The energy efficiency of rail freight transport in terms of aerodynamic drag can be significantly increased by technical and operational measures.
      iii. **Telematics & Electrification and Automatic couplers**: Digitalization and automation are changing processes in many sectors, by offering new services not imagined before. Rail freight is not an exception and it needs to take

advantage of the digitalization, i.e. by improving the management of the wagons introducing IoT by means of telematics, sensors etc. This should be the way to fill the gap to other means of freight transportation and to increase the reliability and efficiency of rail freight. There is a need to develop services according to the demand of each operator i.e. cargo monitoring for logistics, wagon monitoring for maintenance, exact weighing, etc. These services should make use of other services such as positioning and communication with standardized interfaces. Telematics & Electrification of wagons with Automatic couplers will for example enable the following functions:

1. CBM, which will make use of the information collected and transmitted by telematics;
2. Automatic Train Operation where the intelligent wagon together with the automatic coupler, will enable data transmission functionalities needed for supervising train integrity and the train status;
3. Electrification should be responsible for supplying the required energy to the telematics.

The challenge is to demonstrate some of the required systems and services for the intelligent wagon as enabler for further services.

3. **Freight Loco of the future**: New freight products and services require future freight locomotives to be able to offer highest flexibility and availability, everywhere and at any time, and independence from the infrastructure setup. Therefore, the challenge is to increase the modularity and independency from a specific energy source for the traction chain, for instance by further studying hybrid propulsion systems and modular propulsion concepts, distributed power modules and innovative auxiliary networks. Energy efficiency remains a key driver and is an integral part of the challenge.

4. **Long Trains:** The freight sector needs to find ways to rapidly decrease unit costs to improve its competitiveness against the road sector. Major boundaries are the readiness of infrastructure for longer trains and the maximum load on the coupling hook, which limits the maximum weights of trains. Distributed Power in freight trains can solve this problem by distributing the traction and braking forces for long freight trains up to 1,500 m.

5. **Automated train operation (ATO):** ATO is of key importance in helping to ensure that the future European rail freight sector will be attractive and sustainable. It will help to reduce system costs significantly, fostering optimal energy-efficient, low-wear, resource-efficient and flexible operations. It will be essential in terms of achieving the objectives of improved services and customer quality, reduced system costs, enhanced interoperability and simplified business processes.

   As a result of the S2R JU activities, an interoperable, modular and compatible architecture for European ATO over ETCS shall be able to deliver goods safely, reliably and cost-efficiently, making rail the first choice for European freight customers for medium and long distance cargo transportation. The overall aim is to move ahead with the user-centric European development of intelligent auto-piloted freight trains which know their exact position, control the locomotive and wagons under ETCS supervision, react automatically to obstacles, allow better use of bottleneck resources, offer relevant fallback solutions, e.g. remote-controlled driving and run interoperably in different infrastructures on European corridors.

   In order to deploy first ATO technology in European Freight, a paradigm change in the development is needed, which IP5 will drive jointly with the community of European users, based on previous experience and inside of S2R IPs (IP1, IP2, IP5, IPX).

A reference architecture for CCS will be developed in the action to be funded under topic S2R-CFM-IPX-CCA-01-2019. AWP2020 includes the continuation of these activities inside the topic S2R-CFM-IPX and CCA-02-2020. Subsequently, each CFM proposal has to be aligned with the progress in S2R-CFM-IPX-CCA-01-2019 and S2R-CFM-IPX and CCA-02-2020; in particular the system approach and interoperability of solutions must be ensured across S2R IP/CCA activities and for future developments.

SCOPE:

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

The work expected in work stream 1 concerning "condition based maintenance" (TD 5.1) should:

- Demonstrate an end-to-end CBM solution for a European fleet, based on work on Fr8Rail D2.7 'Continuous data transfer from the locomotive to the landsite', Fr8Rail II and S2R-CFM-IP5-01-2019 (TRL 7)
- Provide a proof of concept of brake pad and wheelset monitoring in rail freight, under operational conditions. (TRL 5)
- Based on Fr8Rail D2.6 'Installed Processes', define and test optimized roles & responsibilities in the digitalized maintenance process. (TRL 5)
- Develop user-specific human machine interfaces to test "cooperation" between humans and artificial intelligence. (TRL 6)

The work expected in work stream 2 concerning "Smart Freight Wagon Concepts" (TD 5.3) should:

- Complete freight wagon demonstrator: this activity will deal with the smart Freight wagon demonstrator which is linked to running gear, core market wagon, extended market wagon, telematics and electrification (TD5.3) and the automatic coupler of (TD5.1). Field tests of the 2 developed wagons are expected to be carried out
    - **Core Market Wagon (TRL 7):** definition of a verification and validation plan according to the 5L approach, integration of new subsystems enabling CBM and Continuous System Monitoring (results from the CBM, Workstream Telematics and Electrification of the previous projects FR8RAIL & FR8RAIL II but also will pick-up on the results from the OC Project from 2015 (INNOWAG) into a functional protoype towards smart and connected asset, Validation tests performed in operational environment and documented as demonstration activity.
      Vehicle & Track Friendliness of the developed components should also be assessed by means of verifications as injecting real data in simulation tool.
    - **Extended Market Wagon (TRL 6):** Physical demonstration of the extended market wagon with regards to the structural, aeroacoustical & aerodynamical optimized wagon design concept (wheel-rail interface, life cycle costs, higher speed, track degradation, noise reduction) and novel running gear design concept. Prototype manufacturing of at least one EMW taking into account the S2R-CFM-IP5-01-2019 developed approval concept for the new wagon design. Integration of electrical and mechanical components in the new wagon design.
    - **Telematics and Electrification (TRL 7):** integration of at least one of the telematics product classes including the corresponding subsystems (CMS, WMS, wOBU, FTSMS,EMS) in the extended market wagon and demonstration activities by means of field testing in operational environment.

- **Automatic Coupling (TRL 7):** Integration of the coupler in ideally one of the two new developed wagons. A proof of concept of the Automatic Coupler Demonstrator, in real operational environment, should be performed, according to a pre-defined test protocol covering the most demanding conditions. Specifications review and update are also requested.

The work expected in work stream 3 concerning "freight loco of the future" (TD 5.4) should:

- Better match business request of highest flexibility on the network and of the need for infrastructure independency
- Increase the production network of operators
- further increase the energy efficiency
- Demonstrate new auxiliary network concepts specified in S2R-CFM-IP5-01-2019

The activity, having two distinct focus areas, is expected to finish (1) with a concept for the innovative modular, distributed and hybrid propulsion concept with TRL 3, and (2) with a demonstrator for the auxiliary network concept with TRL 5.

The work expected in work stream 4 concerning "Long Trains" (TD 5.4) should:

- Refine requirements and use cases with additional functionalities (e.g. trains up to 4 locos) for regular usage of Distributed Power in freight trains
- Analyse of relevant infrastructure adaptation and development of migration strategies to bring longer trains in operational service
- Validation in an operational environment of new functions of the Distributed Power technology in trains up to 1,500 m length

The activity is expected to finish with a demonstrator of the new functionalities in a train of up to 1500m length (if supported by the infrastructure) in TRL 7 level.

The work expected in work stream 5 concerning "automated train operation" (TD 5.1) should:

- develop a proof of concept (not tested prototype) for the freight suitable environment sensing systems based on work done in ARCC and S2R-CFM-IP2-01-2019. (TRL 3)
- Define the requirements for freight specific use case automation concepts (GoaA2 and GoA3/4)) for European application based on the work done in ARCC, Fr8Rail-2 and X2Rail-3 in collaboration with S2R-CFM-IP2-01-2019. (TRL 3). (e.g. Remote Control, Automatic loading/unloading, Freight Train Intergrity.)
- Define the requirements of freight specific radio remote control (such as start of locomotive, check the load) of freight locomotives building on results of Long Trains (FFL4E & FR8RAIL-2)(TRL 3)
- Analyse existing EU RU user requirements and specifications (such as start of locomotive, check the load,…) for freight suitable ATO Onboard systems and what will be delivered by S2R-CFM-IPX-CCA-01-2019.

Work-streams results should be placed in the context of the demo plans, which are developed in conjunction with MAAP part B. In addition, the demo plans should be accompanied with integration and migration plans to implement produced solutions in the rail environment to support and speed up deployment.

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 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
- S2R-CFM-IP2-01-2020
- S2R-CFM-IP2-01-2019
- S2R-CFM-IP5-01-2019
- S2R-CFM-IPX-CCA-01-2019
- S2R-CFM-IPX and CCA-02-2020

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

- X2RAIL-3 (GA 826141)
- FR8Rail II (GA 826206)

The action shall actively contribute to the S2R standardisation rolling development plans wherever relevant.

The action shall actively contribute to the S2R KPIs development. This shall lead to publicly available deliverable, quantified indicatively on a semi-annual basis.

The planned activities of the action should take into account the revised MAAP.

The S2R JU will only fund one proposal under this topic.

EXPECTED IMPACT:

The foreseen research activities are expected to contribute to the creation of a framework for an effective railway for freight as a part of the logistical value chain in a more automated way via intelligent equipment and railway terminals enabling the provision of accurate information to end customers and operators.

The foreseen research activities in work stream 1 “condition based maintenance” are expected to:

- Improved services and user quality

- Reduced train composition times (up to 30%), and lower operation costs.
- Reduced system costs
- Enhanced interoperability
- Simplified business processes
- Reduced maintenance costs
- Increased locomotive and wagon availabilities (up to 10%)

The foreseen research activities in work stream 2 “smart freight wagon concepts” are expected to:

- Core and Extended Market Wagon
    - Reducing the weight of freight wagons, to maximise the payload/ deadweight ratio.
    - Significantly contributing to the improvement of reliability
    - Reducing total operating costs for the vehicle and infrastructure by up to 30%
    - Increase aero-dynamical and acoustical performance
    - Increase flexibility in train compositions to maximise logistics capability
    - Maximize track friendliness
    - Optimize maintenance intervals
    - Decrease maintenance costs by providing intelligent assets
    - Providing standard mechanical and electrical interfaces for modular, scalable wagon design for operational interoperability
- Telematics and Electrification
    - Further advancement of the reliability and efficiency of rail freight
    - A significant reduction of derailments through furthering CBM implementation
    - Reaching a 10% reduction of maintenance operational expenses to increase rail freight business competitiveness.
- Automatic Coupling
    - Enable longer trains lengths (up to 1,500m), operating at higher speeds, as a result of increased coupler load transmission capacity
    - Lead to reduced train composition times (up to 30%), and lower operation costs
    - Data and electrical transmission will allow the installation of sensors in the trains, required for an enhanced Condition Based Maintenance, and the possibility to monitor the status of the goods remotely

The foreseen research activities in work stream 3 “freight loco of the future” are expected to:

- Increased energy efficiency
- Improved availability
- Reduced maintenance costs

The foreseen research activities in work stream 4 “long trains” are expected to:

- deliver a Distributed Power technology ready for market entrance;
- enable operators to increase train lengths up to twice the current train lengths and therefore increase their competitiveness rapidly.

The foreseen research activities in work stream 5 “automated train operation” are expected to:

- Enhanced interoperability of European ATO OBUs
- Enhanced interchangeability of European ATO OBUs, reducing LCC by up to 25%
- Compensation of decreasing availability of drivers by use of remote control
- Increased rail freight quality and flexibility using ATO
- Increased resource and capacity utilization using ATO

- Increased energy efficiency by up to 10% due to automatic, dynamic optimization

The research and innovation activities results shall be brought in the form of a demonstrator in the context of InnoTrans 2022, including on the S2R JU stand.

Type of action: Innovation Action (IA)

4.1.7 S2R-CFM-IPX-01-2020: Advanced Functions towards Autonomous Trains

SPECIFIC CHALLENGE:

To provide relevant solutions to mobility needs, railways will benefit from automated and autonomous systems. The STRIA Roadmap on Connected and Automated Transport[37] defines a number of actions to be undertaken by the rail community in the next years in the area of rail automation, among other to develop:

- Reliable environment perception to identify all external hazards and to detect trackside signals enabling onboard decision making intelligence;
- Reliable train positioning;
- Enhanced Train Control and Monitoring System (TCMS), or;
- Reliable external and internal environment perception (outside ATO).

Although activities are currently included within the S2R's MAAP[38], ERRAC has identified several challenges to be addressed in the period 2020 to 2030 in this field[39]:

- Safe, reliable and accurate train positioning, supported by additional sensors to achieve the required performance;
- Advanced TCMS with enhanced safety features fulfilling additional automation requirements;
- A reliable environment perception to enable on-board decision-making intelligence;
- Infrastructure and environment monitoring through sensors and artificial intelligence;
- Self-healing/management of vehicles, intelligent closed-circuit television (CCTV), smart subsystems in general, ready for remote control and supervision.

The challenges brought by STRIA and ERRAC call for additional set of R&I activities to seamlessly bridge the S2R JU and Horizon Europe R&I Programme. The Action should identify and analyse, at system level, what are the potential evolutions of the automation systems starting from what is foreseen now in the S2R JU planning, hence the target of this bridge activity is manifold:

- Exploratory work on new advanced functions complementary to the ATO and TCMS towards achieving full autonomy (GoA4);
- Ensuring standardisation of the new features from their conception following a common European approach;
- Accelerate the deployment of ATO over ETCS, enhance the maintainability and reliability of the delivered ATO specification and validate the stability and performance increase of systems using Automatic Train operation.

A reference architecture for CCS will be developed in the action to be funded under topic S2R-CFM-IPX-CCA-01-2019. AWP2020 includes the continuation of these activities inside the topic S2R-CFM-IPX and CCA-02-2020. Subsequently, each CFM proposal has to be aligned with the progress in S2R-CFM-IPX-CCA-01-2019 and S2R-CFM-IPX and CCA-02-2020; in particular the system approach and interoperability of solutions must be ensured across S2R IP/CCA activities and for future developments.

SCOPE:

[37] https://ec.europa.eu/research/transport/pdf/stria/stria-roadmap_on_connected_and_automated_transport2019-TRIMIS_website.pdf

[38] https://shift2rail.org/wp-content/uploads/2019/05/Draft-Shift2Rail-Multi-Annual-Action-Plan-Part-B-20.5.2019.pdf

[39] Rail 2030: Moving together towards Vision 2050. An agenda for Horizon Europe.

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

The said work-streams are on train external environment perception, on train internal environment perception and on enhanced TCMS including remote operation.

Work-stream 1: Concerning train external environment perception the following activities should be tackled in a coordinated way with TD2.2, TD2.9 and TD5.6:

- Definition and creation of a common database for artificial intelligence (AI) training. Scenarios should cover different markets (high-speed, mainline, suburban, metro, tramway) and different operational conditions. Technical, legal and ethical aspects should be covered (TRL 5);
- Definition of a certification concept for the artificial sense when applied to safety related functions (TRL 3), as the EN50126/8/9 series are fully applicable to AI algorithms. The proposed concept should be assessed by an advisory board composed of NoBos, NSAs and operators;
- Extension of track digital maps with the integration of visual landmarks and radar signatures to support enhanced positioning and autonomous operation (TRL 3). Special attention should be paid to assure interoperability and database efficiency when designing the integration;
- Applicability studies of environment perception technologies (e.g. artificial vision) to a number of use cases (TRL 3), for example:
    - Automatic and optimized door operation to reduce dwell times;
    - Derailment detection of freight trains;
    - Diagnostics and operational state assessment of trains and infrastructure after incidents or accidents, or;
    - Accurate automatic prediction of the braking distance by means of the environment perception and supported by the adhesion management devices, AI and Big Data.

Please note that any proposal that would result in any manner in an upgrade of any signalling Class B system or would contribute to delay their decommissioning will be excluded from funding and most probably result in the partial or full proposal rejection.

Work-stream 2: The action should consider the following activity on train internal perception:

- Enhanced CCTV to prognose and diagnose potential hazard situations affecting security or to improve operation through dwell time optimisation (TRL 3). The following uses cases are examples of potential applications to be analysed within the action:
    - Aggression, harassment and intimidation;
    - Lost luggage or suspicious objects;
    - Asset damaging (e.g. painting);
    - Pickpocketing, or;
    - Actual occupancy and available seats prediction

Work-stream 3: Related to the enhanced TCMS the following activities should be included in the action:

- Definition of a train-to-ground application profile to enable the remote driving of trains through the IEC61375-2-6 standard prepared by TD1.2, over the Adaptable Communication System defined in TD2.1 and secured through the policies established by TD2.2 and TD2.11. The resulting application profile should consider all remote operations onboard staff could perform, like isolating bogies, locking doors or rearming fuses, in order to guarantee the operation even in degraded modes (TRL 4). Reusing the concepts behind the remote hardware-in-the-loop platform developed in TD1.2 should be evaluated. It is also expected this activity to export additional requirements to the communication system (e.g. video streaming for on sight driving, remote virtual driving desk).

- Identification of subsystem tests that could be automated. Pre-design of a number of tests and elaboration of a list of requirements to be exported to such subsystems, if any (TRL 3). In cooperation with TD2.2, which is already working with TD1.2 on the FFFIS interface between TCMS and ATO over ETCS (up to GoA4), extending the TCMS specification (including user stories and use cases) developed in TD1.2 to include possibly new TCMS related requirements relevant to autonomous trains (up to GoA4). These requirements should also relate to TCMS auto-heal functionalities, required to maximise the operational availability and punctuality of the autonomous trains (TRL 3). A reference architecture interfaces should be defined and the system approach validated with the complementary project stemming from the topic "S2R-CFM-IPX and CCA-01-2019: S2R System Architecture and Conceptual Data Model", accordingly to the change management process defined by the S2R JU.

Work-stream 4: Accelerate the deployment of ATO over ETCS, enhance the maintainability and reliability of the delivered ATO specification and validate the stability and performance increase of systems using Automatic Train operation:

- In order to facilitate the migration towards the ATO over ETCS developed within IP2, the proposal should investigate how an on-board ATO over ETCS can still work on a European corridor where a small part of the infrastructure is not yet equipped of ETCS. This activity should be limited to these specific cases scenario with the aim to accelerate the deployment of ATO over ETCS without waiting to have the entire network infrastructure equipped with ETCS. To this aim, this activity should foresee applications for at least three European Countries, considering geographical relevance and without delaying any planned ETCS investment; on the contrary the proposal should justify the choice of the selected Countries explaining why such activity in these Countries will accelerate the deployment of the ATO over ETCS and the overall migration over ETCS.
  The technical activity to be performed requires:
  - Lateral signalling interpretation, taking into account the activities of WS1: to the proposal should consider the lineside signalling in order to determine the equivalent Movement of Authority, to be considered by the on-board ATO over ETCS. This will permit to operate ATO in area not yet equipped by ETCS. In particular, areas equipped with class B systems will be considered or transition to garage yard (TRL 5).
  - Transitions to ATO over ETCS on Class B area: the proposal should define the transition process to transit from an ETCS fitted area to a Class B area and vice versa. This activity should also permit to define how to manage the constraints currently exported to ETCS-OB in order to achieve the required Safety Integrity Level (TRL 5).
  - Standard ATP interface: This activity will define add-ons to current standard interface supported by the SUBSET-130 and the SUBSET-126. These add-ons will permit to manage the specificities related to lineside signalling interpretation (TRL 5).

- The complexity of the ATO over ETCS GoA3/4 system renders difficult to master the maintenance of the related specification documents. Each modification of a document requires to assess the impact on the other related documents impacting the consistency of the overall specifications.
  For these reasons, the proposal should perform :
  - Semi-formal modelling: This activity is going to deliver GoA3/4 specification in a semi-formal model (TRL 3).
  - Prototyping and model simulation: This activity consists in performing prototyping activities using the semi-formal model mentioned before. GoA3/4 state machines will be prototyped in order to validate the concept with railway experts (including drivers). GoA3/4 model simulation will permit to analyse degraded situations based on the conjunction of several anomalies (TRL 3).

- Given the nature of this ATO over ETCS GoA4 system (unattended operation), several functions are exported to the TMS system. The ATO/TMS interaction is fundamental to achieve the expected performances in term of energy saving and operation efficiency.
  Two sensitive topics need to be investigated:
  - Stability analysis: The stability of the integrated regulation loops (ATO/TMS) must be demonstrated in order to validate GoA3/4 specification and functions exported to TMS. This activity will support simulation activities in order to stress the TMS/ATO system based on Use Cases close to reality (TRL 3).
  - Headway analysis: This activity will be based on simulation demonstrating the level of headway performances which are achievable with the TMS/ATO based on GoA3/4 specification and the functions exported to TMS. Headway simulations will be performed on existing lines, existing trains and existing operation scheme (TRL 3).

Please note that any proposal that would result in any manner in an upgrade of any signalling Class B system or would contribute to delay their decommissioning will be excluded from funding and most probably result in the partial or full proposal rejection.

When applicable all work streams of the Action should consider inputs coming from the ongoing activities on the project stemming from the topic "S2R-CFM-IPX and CCA-01-2019".

Work-streams results should be placed in the context of the demo plans, which are developed in conjunction with MAAP part B. In addition, the demo plans should be accompanied with integration and migration plans to implement produced solutions in the rail environment to support and speed up deployment.

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 S2R JU AWP for 2020, in order to facilitate the contribution to the achievement of S2R objectives, the options regarding 'complementary grants' of the S2R JU 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 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: Validation of new technologies for the TCMS
- S2R-CFM-IP2-01-2020: Completion of activities for Adaptable Communication, Moving Block, Fail safe Train Localisation (including satellite), Zero on site Testing, Formal Methods and Cyber Security
- S2R-CFM-IP5-01-2020: Use-centric rail freight innovation for Single European Railway Area
- S2R-CFM-IP2-01-2019: Completion of activities for enhanced automation systems (including Freight ATO GoA4), train integrity, object controller
- S2R-CFM-IPX-CCA-01-2019: S2R System Architecture and Conceptual Data Model
- S2R-CFM-IPX and CCA-02-2020: Evolution of Railways System Architecture and Conceptual Data Model (CDM)

The action shall actively contribute to the S2R standardization rolling development plans wherever relevant.

The action shall actively contribute to the S2R KPIs development. This shall lead to publicly available deliverables, quantified indicatively on a semi-annual basis.

The planned activities of the action should take into account the revised MAAP.

The S2R JU will only fund one proposal under this topic.

EXPECTED IMPACT:

The action should prepare the expected research and innovation activities planned for Horizon Europe (i.e. bridging action) as defined by the STRIA and ERRAC, but also contribute to the general goals of the S2R JU:

- The artificial sense is a key enabler for the autonomous operation in all rail segments, complementing the ATO function and regardless of the existing ATP. Autonomy brings reduced energy consumption (up to 20%) and better punctuality (up to 30%);
- Increased line capacity through reduced dwell times (up to 10%), thanks to the smart door management and optimised train operations. Intelligent doors supporting reduced mobility passengers will also increase the attractiveness of the rail transport and contribute to the modal shift;
- Attractiveness will be also increased by the improved yet no intrusive security, thanks to the AI applied to the CCTV systems;
- Operational reliability will be guaranteed by the enhanced TCMS (up to 50%), which will mitigate the absence of onboard staff to cope with failures and degraded modes;
- Increased energy efficiency to ensure savings compared to conventional driver advisory systems (up to 10%);
- Increased flexibility and quality to ensure more flexible scheduling and stable production are possible, while trains stood or rejected can be avoided;
- Increase punctuality on the lines;
- Enhance interoperability and interchangebility.

The research and innovation activities results shall be brought in the form of a demonstrator in the context of InnoTrans 2022, including on the S2R JU stand.

Type of action: Research and Innovation Action (RIA)

4.1.8 S2R-CFM-IPX and CCA-02-2020: Evolution of Railways System Architecture and Conceptual Data Model (CDM)

SPECIFIC CHALLENGE

The action should build on the existing work on System Architecture and Conceptual Data Model (CDM) and complement the present results, fill the identified gaps and shortcomings and devise ways to improve the uptake across the rail sector and beyond. In order to bring these results to a higher level in terms of quality and adoption, the action shall address the following challenges:

- **Enhance the deployment strategy**

The LinX4Rail project has started the works to overcome the current data and systems fragmentation in the railway sector. The ongoing work is focusing on the creation of the first version of the future

functional railway system architecture, which, complemented with a Conceptual Data Model (CDM), provide a clear path for migration and set the grounds for definying disruptive services and operations.

The path to this target implies a continuous refining of the methodology based on users' feedback, as well as assessing the current level of implementation and learn from it.

- **Ensure wider uptake of results from LinX4Rail**

Based on the initial outputs of the existing IPx action, the challenge is to improve the approach and engage more existing projects across S2R JU IPs and also external initiatives. This could be achieved with a wider promotion of the developed methods and tools as well as a clear uptake from the rail sector and beyond. In addition, the part of the challenge should be the establishment of a single 'repository' for System Architecture and CDM with a well-developed sustainability plan.

SCOPE

Having regard to the Union policies and targets on decarbonisation, taking into consideration that automation and digitalization are key enablers of a drastic railway system transformation, in order to address the challenges described above, the proposals should address all the following work streams, in line with the S2R MAAP:

1. **System Integration and Architecture**

The focus of this work stream should be on refinement of the initial version of the System Architecture developed within the project stemming from the topic "S2R-CFM-IPX-CCA-01-2019". The work should:

- Update the Railway Functional System Architecture based on the latest sectorial intiatives progress, incl. RCA and OCORA results
- Analyse the possible integration of the updated Railway Functional System Architectuture into further Shift2Rail projects (following the Programme Board process)
- Provide clear users's feeback on the way the rail system will be operated in the future and the interconnection with other transport modes and other services
- Define the high-level functions the new operations and services will require and the impact that those could have in the current system
- Take into account the level of advancement already achieved and refine both the methodology and the architecture
- Evaluate business cases of introducing new approaches
- Map standardisation/harmonisation initiatives not yet included in the work of LinX4Rail
- Analyse the potential of business models innovation (disruption) leveraging modularisation and access to internal and external data (based on CDM)
- Further update the migration plan and deployment strategy
- A yearly release of the railway functional system architecture is expected from the project.

2. **Conceptual Data Model (CDM)**

The work should continue on stimulating the uptake of the modelling methodologies by already partnered external initiatives (RTM, EULynx, IFCRail, railML…) and also considering new initiatives (e.g. O&M - SensorML, TransducerML, MaaS API). In addition, the scope of the work includes the following:

- Share object models for free and open use and integration into CDM.
- Analyse and agree on a common data format for interoperability of CDM
- Enable automatic planning of railway assets with CDM
- Establish Digital Twin for supporting predictive maintenance and optimised traffic management
- Ensure these models follow the semantic definitions of the common data dictionary

- Explore ways to enhance/automatise the creation of CDM with the use of Artificial Intelligence tools
- Support the large scale implementation of the S2R JU IP4 ecosystem by ensuring the developed interfaces are in line with CDM
- Increase interoperability in freight transport and improve the intermodal transport chain with the adoption of CDM in IP5 projects
- Ensure alignment on the use of methodologies developed in S2R-CFM-IPX-CCA-01-2019 across the S2R IPs
- Identify and define the common concepts that need to be adapted by all relevant initiatives. For example, define a common way on how lifecycle handling is modelled across all domains (e.g. timetable expiration, new track commissioning time)

Provide a new set of case studies on implementation of the new approach (together with CDM), evaluating benefits and performance increase against deployment/migration cost and LCC reduction. These additional cases should take into account wider initiatives, beyond RCA, OCORA, Eulynx, railML, RTM and IFCRail, and provide additional demonstrators. The work should consider, for example, the ERA registers (e.g. European Register of Authorised Types of railway Vehicles, RINF), national vehicle and infrastructure registers, General Contract of Use for Wagons (GCU), government to business services etc.

Besides the above mentioned work streams, the action should also establish strong communication and dissemination tools in order to promote the Railway Functional System Architecture and CDM, ensure strong visibility and reach a wider audience.

The above work-stream 1 activities are expected to account indicatively for about 70% of the action costs.

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

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
- S2R-CFM-IP2-01-2020
- S2R-CFM-IP4-01-2020
- S2R-CFM-IP5-01-2020
- S2R-CFM-IPX-01-2020
- S2R-CFM-IPX-CCA-01-2019

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

- X2RAIL-3 (GA 826141)
- X2RAIL-4 (GA 881806)
- FR8Rail II (GA 826206)
- CONNECTA-2 (GA 826098)

The action shall consider how to integrate the expertise provided with the S2R JU framework tender "Railway Operators, Staff and Passengers Expertise".

The action shall actively contribute to the S2R standardisation rolling development plans wherever relevant.

The action shall actively contribute to the S2R KPIs development. This shall lead to publicly available deliverable, quantified indicatively on a semi-annual basis.

The planned activities of the action should take into account the revised MAAP.

The S2R JU will only fund one proposal under this topic.

EXPECTED IMPACT

The action should extend the work undergoing the call S2R-CFM-IPX-CCA-01-2019 to cover other identified activities that define parts of railway system architecture and initiatives working on standardisation of data exchange

- Streamlined procurement processes (e.g. CDM-based products, modularity)
- Use of formal verification and system integration of innovative products in the railway system
- Further development of the System of Systems approach, to achieve a full understanding of the rail system complexities
- A rail sector shared vision on how the railway system will be operated in 2030, 2040 and 2050
- Clarity to investors thanks to a clear migration plan
- Creation of (new) enablers for digitalisation, modularisation and automation
- Creation of new innovative services based on the new Functional System Architecture and CDM, leveraging analytics technologies on integrated data, also across IPs
- A set of cases adopting the new approach with well analysed and proven benefits
- Unified integration of external services to the railway ecosystem, increasing attractiveness of rail transport by enabling intermodality and seamless user experience

Type of Action: Research and Innovation Action (RIA)

4.2 ANNEX II – 2020 Calls for non-JU members – Topic descriptions

4.2.1 S2R-OC -IP1-01-2020 Support to Development of next generation of Traction systems (TD1.1)

SPECIFIC CHALLENGE

The Traction Drive sub-system is one of the main sub-systems of a train as it moves the train converting energy from an electrical source (directly or via a chemical source) into a mechanical one.

The physical domains to master are multiple: electrical, mechanical, thermal, and control. A large number of norms and regulations have to be taken into account for traction systems design, manufacturing, validation and certification.

There are two main specific challenges concerning traction systems:

- to master technologies breakthrough developments like SiC semi-conductors applied to different railways traction applications and wheel independent rotating wheels for HST;
- to develop and contribute to implementing new methodologies, tools, norms & standards of noise, reliability, virtual validation and certification, smart maintenance.

Apart from the existing ongoing or finished traction CFM projects (PINTA / PINTA2) complementary work via this Open Call is launched to support the future improvement of the high TRL level S2R JU traction demonstrations on trains done by the S2R JU Members, preparing also future S2R JU key work on domains like digitalisation applied to Traction, environmental sustainability (especially carbon free traction systems preparation) or reinforcement of standardisation to lower complexity and costs.

SCOPE

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

Work-stream 1: 3D additive manufacturing and new manufacturing technologies

3D printing used in Traction is expected to reduce cost and planning on R&D prototypes and to allow higher technical performances to mechanical parts. Investigation on potential also for serial manufacturing, part manufacturing in Service business will be done.

Today R&D prototyping is long and costly. Moreover certain parts with high technical performances are not designed because not manufacturable with classical production means. Opening the 3D printing capabilities will open high technical performances in some parts (e.g. cooling systems) while reducing cost an duration of prototyping. Serial manufacturing could benefit from this technology (as already implemented in the avionic sector).

The objective of the work is to investigate this new opportunity to reduce the Traction Capital Cost KPI and improve technical performance (TRL 3).

The main expected results are:

- new processes (design, manufacturing, validation),
- new technologies (powders, 3D printing machines),
- better understanding of the potential benefit of 3D Printing on Traction active components (e.g. motor including sensors) and parts.

Work-stream 2: Wireless Dynamic Charging for urban vehicles based on SiC semi-conductors

The combination of high frequency SiC devices with dynamic wireless charging will increase the efficiency and the transmission distance of wireless charging systems. With an optimized coil design the transmission can be carried out while the vehicle is moving.

The Energy efficiency and Reliability/Availability Traction KPIs are targeted because of better recharging solutions than currently available.

New work is needed in this domain because the transfer efficiency of wireless charging systems increases with frequency and due to the frequency limits of current Silicium Traction devices, the benefits of wireless charging are not actually exploited to their best.

The objectives is TRL 3 on the design of a high efficient wireless dynamic charging system to supply a tramways power train and to charge the batteries of catenary free tramways while the vehicle is moving.

The main expected results are:

- downsizing the on board energy storage system,
- reduction of the demanded peak power,
- full catenary free operation.

Work-stream 3: Investigations on reliability of traction components and lifetime mechanisms

The main content of the work is the reliability and lifetime tests executed by an independent laboratory for power semiconductor devices. The work is a supporting action for the S2R-CFM-IP1-01-2020 and could help the S2R JU into the standardisation activities.

Reliability and Maintenance costs KPIs are targeted to be improved.

The objectives (TRL 4) are to receive basic data and define validated lifetime models for power semiconductor devices (especially SiC) based on the measurements.

The main expected results are: validated lifetime models which can be implemented into engineering tools for reliability and lifetime calculation depending on the specific train operation

Work-stream 4: Big Data, Artificial Intelligence (AI) applied to Traction systems smart and predictive maintenance.

The intention is to share knowledge from non S2R JU Members experts on data mining and AI with the future Traction CFM projects (S2R-CFM-IP1-01-2020).

The work is targeting reliability improvement and maintenance costs reduction.

In more detail, to handle the huge amount of data generated by smart maintenance applications (including sensor data), expertise in the field of Data Mining and AI is needed. This expertise will help to evaluate the requirements and structure for the data collection to ease the use of Data Mining & AI to get added value knowledge out of the rough data.

The aim is to consider the respective methods of Data Mining & AI taking into account the input that the S2R JU complentary IP1 CFM project will provide during the project execution.

The main objectives (TRL 4) are a support to choose a certain concept on Smart Maintenance helping to improve predictive maintenance on traction power conversion components.

Studies on different Data models and selection on different AI methodologies, advantages/disadvantages of approaches and link with train data normalisation (studied at train level) are expected.

Proposals answering to this topic can also make use of PhD thesis.

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 S2R objectives, the options regarding 'complementary grants' of the S2R JU 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 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-IP1-01-2020

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

- IMPACT-2 (GA 777513)

EXPECTED IMPACT

Expected global Traction OC Impact: The most significant benefits from the action as a result of the new approach breakthroughs in Traction domains are an extension on know-how in different fields like R&D methodology, technologies, approaches and norms to support CFM Traction TD1.1 work and bring complementary improvement on several Traction KPIs : Life Cycle Cost reduction (capital cost, energy, maintenance), reliability improvement, noise reduction.

What is expected -from the global seven work-streams- the following indicative values improving the S2R JU Traction TD demos

- Additional -20% Traction manufacturing Cost and -50% of R&D parts prototypes manufacturing planning.
- Additional -5% of Energy Cost on traction power
- Additional +10% of power semi conductors reliability/maintenance cost reduction

Type of Action: Research and Innovation Action (RIA)

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 complmentarity, the action stemmed form this toic is expected to take as a reference the output in the field of the project S2R X2Rail-3[40].
- Work-stream 2:

[40] Expected to be delivered in November 2020.

    - Subsystem functions adapted to Application Profiles[41] 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 6/7[42].
- FDF HW platform and development environment with a TRL 6/7[43].
- Time Sensitive Network Configuration Tool with a TRL 6/7.
- Wireless Train Backbone equipment[44], such as the Wireless Train Backbone Node and Antennas with a TRL 6/7[45].
- 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 below[46] :

- 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

[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

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 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)

4.2.3 S2R-OC-IP1-03-2020 Innovative technologies for Carbodies and Running Gear of the future

The project funded under this action covers three topics for two TDs: carbody (TD 1.3) and running gear (TD 1.4).

SPECIFIC CHALLENGE

Carbody

The proprosal is to complement the carbody developments and activities within the S2R JU programme, especially within the S2C-CFM-IP1-01-2019. These activities are described globally in the S2R MAAP and the S2R-CFM-IP1-01-2019 specification of the AWP 2019. The detailed information about the scope of the Open Call contribution is inspection methods for new materials adapted for the maintenance in railway environment.

On the new generation of carbodies the inclusion of different combination of materials (metal alloys and composites) to achieve the proper balance between cost, weight and performance require specific efforts not only in the design and manufacturing phases but also for maintenance of the Rolling stock. To that end specific development should be done in the phase of inspection process of the carbodies in service to adapt the solution to the railway environment.

Running Gear

The proposal is to complement the running gear developments and activities within the S2R JU programme, especially within the S2C-CFM-IP1-01-2019. These activities are described globally in the S2R MAAP and the S2R-CFM-IP1-01-2019 specification. The detailed information about the scope of the Open Call contribution is mentioned in the following work-stream: Innovative approaches to contribute to running gear development progress

New technological solutions for running gear need to have sufficient durability to operate between overhauls or even through the entire vehicle design life of up to 40 years. Especially for elastomeric material and journal bearings this is a significant challenging factor.

The challenge is to develop innovative approaches to contribute to running gear development progress related to light, silent, track-friendly, and reliable, LCC running gear components. This multi-technology approach will have to address several functions (comfort, curving, structural function, rolling components, health monitoring, etc.).

SCOPE

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

Work-stream 1 (on carbody): Inspection Methods for new materials adapted for the maintenance in railway environment

1. Development of new methods of inspection applicable for composite and hybrid carbodies/components using non-destructive testing from only one side (exterior side), valid for monolithic panels or sandwich. TRL 4/5
2. Development of the equipment at prototype level.
3. Application of the new methods and equipment after the testing campaign.

Work-stream 2 (on Running Gear): Innovative approaches to contribute to running gear development progress should include tools, methodologies and technological development in the following areas:

1. New elastomeric materials with enhanced lifetime (TRL 3/4)

   Elastomeric materials are widely used in the Railway sector and more deeply in rail vehicles. Components like springs, airbags, bump stops and bushings are made of elastomeric materials, usually of both natural and synthetic rubber. The main drawback of these components is the relatively short maintenance period and lifetime due to the natural ageing of rubber compared to metallic components (i.e. coil springs) usually designed to withstand whole vehicle lifetime.

   New Elastomeric Materials should provide in this regard enhanced durability to levels of metallic components and maintaining its mechanical properties for the complete lifetime.

   New material shall be capable of being industrialized and manufactured in serial production for the typical Elastomeric Components in the railway field.

   The result of this study is the validation of the new material at component level (lab tests). Additionally it shall be manufactured railway components to be tested in field application.

2. New Journal Bearings with enhanced LCC and lifetime (TRL 3/4)

   Existing technology of journal bearing show a relevant LCC that represent a significant cost of the running gear maintenance. For a journal bearing the LCC is derived mainly from the lifetime and maintenance/Inspection period and in minor importance of acquisition cost.

   Therefore the action should investigate the development of a new technology of journal bearings that provides a significant improvement regarding lifetime and reduced periods of maintenance.

   This new development can be based on improving existing greases and/or optimizing roller elements, cages and race, both geometry and material.

   The focus should be directed to the high speed application conditions/ requirements as described in SPD1 by the IMPACT project (GA 730816) (D4.1 - Reference Scenarios). Current estimated maintenance period for such bearing can be considered as 2.5 Mkm

An indicative scheduling of the deliverables is suggested below[47] :

- Deliverable under work-stream 1-1 is expected by M14
- Deliverable under work-stream 1-2 is expected by M23
- Deliverable under work-stream 1-3 is expected by M35
- Deliverables under work-stream 2 are expected by M24

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 Agreement and the provisions therein, including with regard to additional access rights to

[47] 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

background and results for the purposes of the complementary grant(s), will be enabled in the corresponding S2R JU Grant Agreements.

The action 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-IP1-01-2019: Development of new technological concepts towards the next generation of rolling stock, applied to major subsystems such as Car body, Running Gear, Brakes, Doors, Modular interiors and HVAC.

EXPECTED IMPACT

For Work-stream 1 (on carbody): new skills and methodologies available for railway sector, reduced dwell time due to inspection of the new generation of the rolling stock. It is also expected to make the inspection of the carbody in 12 hours.

For Work-stream 2 (on running gear): activities are expected to contribute to the running gear work streams according the MAAP:

- Developing an understanding of the opportunities and risks presented by new elastomeric materials with a focus to increase the lifetime and reduce the LLC. New materials have to resist the lifetime of 25 years without losing significant performance, without increasing the maintenance costs and providing 100% safety. The new solution has to improve the total cost saving by 15% compare the parts in use today without changes of the space envelope.
- New approaches of bearing systems have to contribute to a maintenance cost reduction by increasing the lifetime to 25 years (without losing significant performance, without increasing the maintenance costs and providing 100% safety) or by proposing innovative system with simple maintenance/overhauls in without disassembling. The new solution has to improve the total cost saving by 15% compare the parts in use today for the SPD1 without changes of the space envelope or bearing concept

Furthermore, the activities are also expected to contribute to the following key S2R JU objectives:

- Vehicle weight reduction by 50% through the use of new concepts based on lighter materials. This weight reduction will have several side effects such as:
    - Reduction of the energy consumption of the vehicle
    - Increased track friendliness
    - Additional freedom for vehicle design
- Reduction of the LCC by 50% of the vehicle and the whole railway system, derived from the reduction of track damage due to the reduction of mass and the improvement of guidance ability of running gear, and improved health monitoring supported by new running gear sensor systems, which will contribute to a cost reduction of up to 20%.
- Increase in operational reliability and composite material acceptance supported by better performing health monitoring and sensor systems, which will contribute to a cost reduction of up to 20%.

Type of Action: Research and Innovation Action (RIA)

4.2.4 S2R-OC-IP2-01-2020 - Modelling of the Moving Block system specification and support for Railway Minimum Operational Performance Standards

SPECIFIC CHALLENGE

The objective of the call is to delineate, through system models of Moving Block, the behaviour of the system in order to identify potential additional hazards due to the introduction of the Moving Block in the diverse market segments and with the diverse signalling systems. This will support the activities of the Technology Demonstrator and help bringing the developments not only as close as possible to the market but also support the possible update of the regulatory framework.

In the field of Train Localisation (based on the use of combined technologies such as for example EGNSS, IMU, kinematics, Digital Map) the main objectives are to contribute with enhanced railways Fault Detection and Exclusion algorithms for facing local feared events, data fusion algorithms suitable for railway safe applications, EGNSS monitoring techniques also based on carrier phase measurement and multi-frequency technology, and to provide Independent Assessment Report on the proposed technologies and solutions, in accordance with the objectives of the IP2 TD2.4 Fail Safe Train Positioning (including GNSS) described in the S2R MAAP.

SCOPE

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

Work-stream 1:

Within the framework of the Moving Block the proposal has to carry out the following work:

a. To create semi-formal or formal models of the Moving Block systems, which have been defined by the work in S2R X2Rail-1[48], and by using the Formal Method methodology developed in X2RAIL-2[49], in order to examine the system behaviour, and check for additional hazards arising from the use of Moving Block. The action could also consider the method included in the EULYNX Modelling standard[50].
b. To update the above modelling based on the updates to the Moving Block specifications which will result from the work in S2R X2Rail-3[51] (based on the deliverables from X2RAIL-1).
c. To create semi-formal or formal models of the enhancements to the Moving Block architectures, as proposed by the "Future Moving Block Architectures" topic within the project S2R X2Rail-3[52]. The method used should be the same as used for modelling the results from X2Rail-1.

Expected TRL: 3

This work should be performed in collaboration with work carried out within the action stemming from the S2R-CFM-IP2-01-2020. It is expected that the Open Call will present the results of the modelling to the CFM project.

[48] Deliverables related to WP5 of X2RAIL-1 (moving block) are publicily available on the project website (results and publication): https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-1

[49] Delierables related to WP5 of X2RAIL-2 (formal methods) – D5.1: https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-2

[50] EULYNX Modelling Standard - Published by EULYNX at www.eulynx.eu (EULYNX Document Number: Eu.Doc.30)

[52] Expected to be delivered in May 2020

Work-stream 2:

Within the framework of the Fail Safe Train Localisation, the proposal has to carry out the following work:

a. Perform a review of feared events (both system and local) and characterise threats in terms of their impact on code and carrier phase measurements;
b. Definition and Development of Railway Fault Detection and Exclusion (FDE) algorithms for coping with railway system and local feared events in the context of both mono/dual constellations and mono/dual frequencies; in the context of these FDEs, perform a technology assessment and review of the state of the art for methods and techniques to improve the robustness of carrier phase tracking in the railway environment, to enable use of carrier phase measurements as possible monitoring techniques;
c. Definition and Development of Data Fusion algorithms among different possible technologies such as for example EGNSS, IMU, Kinematics, Digital Map suitable for providing a safe position in the position domain along with the associated integrity (e.g. accuracy, integrity risk, confidence interval along the track, time to notify alerts to the consumer of the position information);
d. Select candidate techniques and algorithms for the implementation of a Proof of Concept;
e. Specify (including respective safety analyses), design and develop a Proof of Concept implementing the selected techniques and algorithms;
f. Test and assess performances in a real or simulated railway environment;
g. Independent Assessment Report, done by a Notify Body, on the developed Proof of Concept;
h. Contribution to the definition of the Railway Minimum Operational Performance Standards and the trade-off analysis about the use of the Standard SBAS (e.g. EGNOS) augmentation systems.

Expected TRL: 3

An indicative scheduling of the deliverables is suggested below[53]:

- Deliverables under work-stream 1 is expected by M20. Deliverables under work-stream 2 is expected by M12.

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 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.

[53] 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

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-IP2-01-2020: Completion of activities for Adaptable Communication, Moving Block, Fail safe Train Localisation (including satellite), Zero on site Testing, Formal Methods and Cyber Security

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

- X2RAIL-3 (GA 826141)

EXPECTED IMPACT

Regarding the work-stream 1 the activities are expected to contribute to:

- Improvement of the technical coherency of the Moving Block system specifications being defined within the action from the S2R-CFM-IP2-01-2020. Thus improving the process of application of Moving Block signalling. Moving Block signalling in turn will contribute towards increased capacity (up to 50% for high speed and freight most notably), reduced life cycle costs, and improved reliability, depending on the type of railway.

Regarding the work stream 2 the activities are expected to contribute to:

- Improved knowledge regarding the application of RAIM algorithms in Railway and on the performance achieved with the use of the standard SBAS augmentation systems.

Type of Action: Research and Innovation Action (RIA)

4.2.5 S2R-OC-IP2-02-2020 – Study on alternative bearers and on communication protocols

SPECIFIC CHALLENGE

The objective of the call is to investigate alternative communication means and solutions, which can be used in addition or for complementing the current standards for specific needs and/or for being implemented in well-defined and restricted areas. The objective is to improve the system adaptability in view of the application of full bearer independency defined in the framework of TD2.1. The action shall also address a study for identifying the best use the current communication protocols in view of streamlining the application according to the needs.

SCOPE

The aim of the work is to assess two studies that complement the main stream work in the field of alternative communication bearers and of communication protocols. The study on alternative communication bearers in the railway environment shall identify, assess and analyze alternative bearers in addition and beyond established radio technologies (UMTS/HSPA, LTE, LTE-A, Wi-Fi/802.11, SatCom, etc.). The availability of the alternative bearers might be restricted to certain areas (for example train stations, shunting yards, high-speed lines, different terrains, etc.), related to specific railway infrastructure installations or ubiquitously available. The alternative bearers could rely on or leverage already available infrastructure or equipment alongside the railway tracks. Some potential candidates include but are not limited to data over power lines, free space optical communications, etc.

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

Work-stream 1: For what concerns the study of the communication bearers the action shall:

a. Describe the alternative bearers from a technology perspective;
b. Qualify the benefits and challenges of the bearers, taking into account operational and economic considerations;
c. Outline the dependencies to infrastructure or other environmental preconditions;
d. Compare the expected communication characteristics with well-established wireless technologies in terms of (but not limited to) average/maximum/guaranteed throughput, packet delay, packet jitter and other attributes such as Quality of Service support, resource management, multi-user / multi-application capabilities;
e. Provide a recommendation or classification of bearers related to certain railway environments and further work in terms of technology and business case development.

Work-stream 2: For what concerns the study of the communication protocols the action shall:

a. With the convergence of network protocol layer towards the Internet Protocols to identify the appropriate transport protocol for ensuring communication characteristics and capabilities during application development;
b. Analyse interworking between Internet Protocol v4 and Internet Protocol v6;
c. Analyse the different options for the transport layer (UDP, TCP, SCTP , etc.) and the application layer protocols (HTTP, QUIC, SIP, etc.) with the aim to narrow the selection for certain application requirements, qualifying the protocols in terms of technology features like flexibility, latency and prioritization as well as operational considerations including engineering and implementation complexity, monitoring and debugging capabilities;

d. Analyse the security of the transport and application layer with using the secure version of protocols, e.g. SFTP or SCP instead of FTP, or HTTPS instead of HTTP or combining the protocols with application security.

An indicative scheduling of the deliverables is suggested below[54]:

- Deliverable (e) corresponding to work stream 1 is expected by month M12
- Deliverables a, b, c, d under work-stream 2 are expected at the latest by month M18

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 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-IP2-01-2020: Completion of activities for Adaptable Communication, Moving Block, Fail safe Train Localisation (including satellite), Zero on site Testing, Formal Methods and Cyber Security

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

- X2RAIL-3 (GA 826141)

SPECIFIC CONDITIONS FOR PARTICIPATION

In accordance with Art. 9(3)(d) of the HORIZON 2020 Rules for Participation, in this specific topic the minimum condition shall be the participation of one legal entity established in a Member State or Associated Country. The reason of this approach is justified by the technically specific nature of the expected activity that would not require a significant amount of investigation and cooperation.

EXPECTED IMPACT

- The identification and analysis of new alternative communication bearers is expected to support the goals of the adaptable communication system (TD2.1) enabling new communication services for implementing future railway requirements. This will help reducing (estimated 50%) lifecycle costs.

[54] 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

- Increased possibility of bearers to be used by the new communication system therefore increasing operational flexibility.

Type of Action: Research and Innovation Action (RIA), TRL up to 4/5

4.2.6 S2R-0C-IP3-01-2020: Next Generation Track Transition Zones

SPECIFIC CHALLENGE

The forecast demand for increased capacity throughout the European rail network over the next few decades, together with the need for improved reliability and punctuality, requires an innovative approach to track design, installation, maintenance and operation. The current, first project within TD3.4 'IN2TRACK2: Next Generation Track' (GA 826255) explores potential technologies, together with innovative condition monitoring and maintenance processes to provide a step change in reliability, availability and performance of plain line track, targeting a time horizon of around forty years beyond current state-of-the-art. The primary objective is to achieve this improvement without being restricted to current practices, whilst retaining key railway functionality. As such, all present perceptions regarding design, maintenance, operations, etc. are being revisited with a much more open frame of mind.

It is recognised that a key factor in enabling the required step change in performance of the track asset is provision of optimum track support conditions within transition zones. These include locations of abrupt changes of track support, typically where plain line track abuts the following features:

- switch and crossing units;
- underbridges or other structures;
- change of track construction (e.g. ballasted to direct fastened track).

The specific challenge is to ensure that the transition zones associated with next generation track solutions provide a sustained, smooth transfer between areas of differing support stiffness. Track stiffness is a key factor affecting operational performance and asset life. If the track support is too soft or variable over a short distance, excessive deformation and deterioration of track geometry may result. However, an overly high support stiffness may cause damage to components, such as rails and fastenings.

Within transition zones, an abrupt change of track support stiffness can lead to significant differential settlement. For ballasted track, this will often result in voiding beneath the sleepers and poor track quality, which in turn increases the dynamic load. This can lead to further settlement, noise and vibration and localised loss of support to the rail, potentially resulting in rail failure, if not adequately addressed.

Transition zones can be difficult and costly to maintain. Transitions from ballasted track onto structures can present a particular challenge. To manage the track geometry, manual lifting and packing is often required, as it is not always feasible to use standard maintenance machines due to the proximity of the bridge deck, especially with direct fastened track. To meet the objectives of TD3.4, next generation transitions should provide optimum and sustained track support conditions, with minimal requirement for maintenance intervention, to prevent the potential for service affecting delays.

SCOPE:

Proposals should complementing the next-generation track system development activities within the S2R JU programme, especially within the action stemming from the S2R-CFM-IP3-01-2020 topic. These activities are described globally in the S2R MAAP –TD3.4 and the S2R-CFM-IP3-01-2020 topic description.

In order to address the challenges described above, proposals should address all the following work streams, in line with the S2R MAAP and with the public deliverables from the project "IN2TRACK" (GA 730841):

- D2.1 'Identifying and Understanding Core S&C Issues'
- D2.2 'Enhanced S&C Whole System Analysis, Design and Virtual Validation'
- D2.3 'Enhanced monitoring, operation, control and maintenance of S&C'
- D3.1 'Enhanced track structure – Status, key influencing parameters and prioritised areas of improvement'
- D3.2 'Enhanced track design solutions through predictive analyses'
- D3.3 'Enhanced inspection, maintenance and operation of track'
- D4.2 'Improvement of tunnels and bridges'

and from "S-CODE" (GA 730849):

- D1.1 'Review of definitions, standard operating parameters, best practice and requirements, including future technologies and horizon scanning'
- D2.1 'High level architecture design document'
- D4.1 'Novel materials and additive manufacturing processes, including opportunities to improve logistics and installation'
- D4.2 'Integration and optimisation of switch and substructure technologies'

Proposals should form the first stage in development of a full-scale next generation transition zone demonstrator, as part of a whole system solution to provide a step change in asset performance and lifecycle cost. Proposals answering this topic should deliver the following:

- protypes and small-scale demonstrators of next generation transition zone components and sub-systems to TRL 5, to validate the next generation transition zone design and simulation;
- Detailed design and technical specification for physical transition zone demonstrators - to be implmented by the S2R-CFM-IP3-01-2020, compatible with relevant outputs of other IP3 CFM projects;
- installation, maintenance and decommissioning requirements to support whole life costing, to quantify business benefits;
- specifications for component and system design and testing criteria, to allow industry implementation of feasible solutions.

The proposed research and development shall address the following tasks, in line with the S2R JU MAAP:

- development of next generation track transition zone solutions, taking account of the following:
  - optimised whole system stiffness, in the frame of the technical complementarity with the research and development on enhanced and next generation track technologies carried out in IN2TRACK-2 (GA 826255);
  - development of integrated/embedded condition monitoring solutions, as part of the transition zone design;
  - design and materials to provide sustainable, whole system solutions to minimise maintenance interventions, noise and vibration, environmental impact and carbon footprint whilst ensuring system resilience against climate change;
  - development of optimum maintenance regimes, to minimise disruption to the operational railway;
  - system boundaries to extend from the natural sub-soil (i.e. beneath the sub-grade and track formation layers) to the wheel-rail interface.

- development to apply a CSM-RA for Hazard Identification (HAZID) and mitigation for all stages of the asset lifecycle, including but not limited to:
    - utilisation of novel materials;
    - optimised design for reliability;
    - manufacturing techniques;
    - installation methodologies;
    - maintenance requirements; and
    - decommissioning
- development of LCC and RAMS performance models, including a full cost/benefit analysis, with due consideration to all anticipated operational and environmental conditions.
- Design and specification for monitoring equipment required to validate the transition zone demonstrator within the S2R-CFM-IP3-01-2020 project.
- Support for integration of the transition zone design into the whole-system next generation track technical demonstrator developed within IN2TRACK-2 and S2R-CFM-IP3-01-2020. This call shall demonstrate compatibility with the technology demonstrators developed within these projects.
- Development of simulation models to support validation of the final transition zone designs for a range of applications, to include the transition between next generation plain line track and:
    - existing track construction types;
    - switch and crossing units;
    - underbridges;
    - other structures, tunnels, etc.

The next generation track transition zone demonstrators should reach TRL 5

An indicative scheduling of the deliverables is suggested below[55]:

- Technical specification for transition zone: M9
- Detailed design: M12
- Simulation model: M14
- Technical specification for monitoring: M16

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 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:

[55] 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

- S2R-CFM IP3-01-2020: Research into optimised and future railway infrastructure

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

- IN2TRACK-2 (GA 826255)

IMPACT

The output of this project will contribute towards achieving the S2R MAAP objectives, in the following areas:

- reduction in service affecting delays due to fewer track geometry defects and associated rail failures;
- reduction in noise and vibration at the transition locations, due to provision of a sustained, smooth transfer between areas of differing support stiffness;
- lower lifecycle cost due to a reduction in maintenance and extended operational life of the track and associated assets.

The above will be demonstrated by the cost / benefit analyses carried out for the different operational environments considered.

Type of Action: Research and Innovation Action (RIA)

4.2.7 S2R-OC-IP3-02-2020: Technology Development for Railway Systems Asset Management (TD3.6)

SPECIFIC CHALLENGE

Railway infrastructure maintenance has a key role in annual operational costs. Current technologies provide predictive decay of railway assets used for operational activities planning. The usage of new technologies concerning prescriptive analysis to suggest actions through a decision support system, can contribute to reduce life cycle costs. The challenge is to use prescriptive analytics to provide not only a prediction of future issues but also to provide solutions for preventing and solving them. The objective is to move forward the research activities currently under development in IN2SMART (CFM) and in IN2DREAMS WS2 (OC) S2R JU projects, in order to develop an Intelligent Asset Management System (IAMS) in the railways context.

SCOPE:

Proposals should complementing the DRIMS development, and activities within the S2R JU programme, especially within the S2R-CFM-IP3-01-2020. These activities are described globally in the S2R MAAP –TD3.6 and the S2R-CFM-IP3-01-2020 topic description.

The expected goal concerning the **"**Dynamic Railway Information Management System (DRIMS)" (TD3.6) is to provide technology validation of:

- Prescriptive data analytics[56] tools to implement a Decision Support System (DSS), with man in the loop, for IAMS. The tools should be able to prescribe maintenance actions using data from heterogeneous sources, covering multiple aspects of the railway world. Prescriptive analytics will use a combination of techniques ranging from basic statistics up to machine learning and artificial intelligence (e.g. learning from efficient human behaviours) technologies.

- Multi-objective decisions' optimization tools for IAMS integrating data-driven models into the DSS based on a combination of techniques ranging from mathematical computational model up to artificial intelligence optimization. The tools should be able to dynamically assess multiple risks (e.g. network/operations unavailability, maintenance extra costs, contractual penalties, etc.) of prescriptions managing data and decision uncertainty.

In order to exploit both prescriptive analytics and optimization tools results and to provide them to operators, TD3.6 has to provide also technology validation of:

- Sensitivity analysis methodologies to be applied to both prescriptive analytics and optimization tools (see above bullets), supporting the maximization of consistency and quality of decision-making.

- Context based dynamic human machine interface supporting the DSS operators to manage prescriptive analytics and optimization tools.

All the above shall be developed starting from the results of IN2SMART (D2.2, D8.5, D9.1) and IN2DREAMS WS2 (D5.1, D5.3) S2R JU projects[57].

Proposals should:

- Include at least a railway use case with a sufficiently complete dataset to allow prescriptive analytics.
- Allow the validation of results on another use case provided by the S2R-CFM-IP3-01-2019[58].
- Consider the application of multi-modal transport solution for mitigating the impact of maintenance decisions and infrastructure possession planning.

This work is expected to deliver a TRL 4/5 prototype contributing to the ITDs that will be developed in the S2R-CFM-IP3-01-2019 project.

An indicative scheduling of the deliverables is suggested below[59]:

M10: General requirements; preliminary results related to railway proprietary use case;

M14: Preliminary results related to TDs S2R JU community use case.

[56] Prescriptive Analytics is a form of advanced analytics which examines data or content to answer the question "What should be done?" or "What can we do to make it happen?" https://www.gartner.com/it-glossary/prescriptive-analytics/

[57] Accessible here: https://projects.shift2rail.org/s2r_ip.aspx?ip=3

58 Accessible here: https://projects.shift2rail.org/s2r_ip.aspx?ip=3

[59] 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

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 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 IP3-01-2019: Intelligent asset management finalisation

EXPECTED IMPACT

Actions will contribute to achieve an increase of the attractiveness and competitiveness of the railway transport in Europe through an efficient, safe, intelligent infrastructure maintenance approach. Expected impacts in detail are:

- Balanced, controlled, cost and risk-effective interventions in between railway services and maintenance.
- Increase operational reliability by 30% through less service disruption, improving users railway attractiveness.
- Optimize maintenance execution by 30% through the multi-objective decisions' optimization tools.
- Life cycle costs reduction by 20%.

Type of Action: Research and Innovation Action (RIA)

4.2.8 S2R-OC-IP3-03-2020: Advanced tools and equipment: collaborative robots & wearable mobile machines (TD3.8)

SPECIFIC CHALLENGE

As described in the MAAP, for TD 3.8 one of the focal areas is new and advanced working methods, tools and equipment and logistics solutions, supporting the LEAN execution of intelligent maintenance processes. For this topic two work streams are defined with each a specific challenge:

- Work stream 1: the challenge is to move forward the research on robotics and make robotic principles rapidly applicable for the rail sector using existing plant (machines and equipment) as a starting point. Currently the primary method of plant control are human operators. This creates a significant risk of incidents caused by human error. There is a great reliance upon

compliance and individual competence, which is not always robust. Giving existing plant a level of autonomy and intelligence using the robotic principles, could help to avoid incidents where plant strikes other plant, plant strikes an individual or plant strikes a piece of infrastructure. Introducing this level of autonomy should make the collaboration between current plant and machine operations and personnel on the track around the plant possible. On top of that, some of the tools being used in the track are heavy and, using these tools, requires physical effort that will cause damage to the human body over time. Introducing robotics principles moving and using these tools can be seen as part of the challenge.

- Work stream 2: the challenge is to equip railway workers who handle heavy tasks with load carrying exoskeletons to minimize muscular fatigues. Long term benefit by avoiding health issues are the main driver. Many workers performing heavy physical tasks are affected by musculoskeletal disorders, leading to a huge annual cost. Exoskeletons have the capacity to decrease the number of musculoskeletal injuries and increase quality of life at work, thereby reducing costs for a company in the long run.
  The developments around exoskeletons are rapid meaning that these can now offer partial, passive, or agile support with a decreased price tag. Exoskeletons designed for performing manual labour tasks in industrial environments are now commercially available. For successful use in the rail sector, extra requirements come related to the more robust environment come into place. For this work stream, the challenge is to address these requirements and present a successful demonstration.

SCOPE:

Proposals should complementing the IAMS development, and activities within the S2R JU programme, especially within the S2R-CFM-IP3-01-2020. These activities are described globally in the S2R MAAP – TD3.8 and the S2R-CFM-IP3-01-2020 topic description.

Within S2R JU IP3 work is being undertaken to develop a generic robotic platform to support future inspection and execution of maintenance actions (In2Smart - GA 730569). Especially work stream 1 fits in the same context as described above to develop and test new automated and smart working tools and equipment, demonstrating that existing tools/equipment can be transferred easily into robots letting these to make decisions.

For this work stream the idea for this call is to use the principles developed for this robot platform, such as a central control unit using ROS – Robot Operating System (an open-source, meta-operating system for robotics), to give current plant equipment and on track machines (OTM) a level of autonomy or transfer it to a cobot (collaborative robot), in order to physically interact with humans in a shared workspace. Also the aspect of moving tools and equipment to the place of execution can be included. This can either be moving autonomously or creating the tool of equipment as an add-on to, for example, excavator.

To summarize: making existing plant/equipment multi-purpose and autonomous using ROS and other robotics principles.

Expected result of the action is standalone demonstration of an improved existing plant (machines and equipment) by integrating robot technology (ROS) giving it a level of autonomy and/or the capability to move without being directly operated by humans. Interaction with humans, avoiding, is in an imported feature to be included.

Possible examples of current plant equipment and OTM are:

- Rail Excavator,
- other multi-purpose rail equipment and tools for reprofiling and deburring tools, weld trimmers etc.

For work stream 2 the idea is to deliver an exoskeleton which can be used outside in the rail track performing a set of different maintenance task. Since the working conditions are robust, the exoskeletons have to made suitable for these outside situations. The exoskeletons have to be made ready for heavy duty use. The weather conditions are one: water resistance is obvious. But also the use under different extreme temperatures (indicatively -20 + 50 Celcius degree). An exact level of protection expressed in the International Protection Marking, IEC standard 60529, should be part of the requirements definition, but probably IP67 or higher.

Track workers perform often a variety of tasks and move from one spot to another. Idea is that the exoskeletons can be used during a whole shift and are suitable for multiple tasks and moving between tasks. This requires special attention to comfort, such as weight and possibility turning assistance off. Tasks can include work bending over, sitting on haunches or raising arms above shoulders.

Concerning safety: the exoskeleton should not introduce new safety issues for the users, existing safety issues should be addressed. This means that integration with existing required Personal Protective Equipment (PPE) is part of the complexity. Weight of the exe-skeleton should be below 10Kg.

In order to reach the required high TRL, it is necessary to make choices around the scope. Therefor a focus for the type of exoskeleton, active/passive of hybrid, and application (which tasks) in the sense which part of the body is supported, might be necessary. Proposal should include a clear use case specifying the type of support the exoskeletons will give (arms, legs or (lower) back) type of exoskeleton and which range of tasks

This both work-streams the work is expected to deliver a TRL 5/6 prototype.

An indicative scheduling for both work-streams of the deliverables is suggested below[60]:

M8: General requirements : scope definition of proposed use case (including the choice of existing equipment to be used as an example work stream 1 and set of tasks for work stream 2) defined and agreed;

M14: First results presented as demonstrator

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 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.

[60] 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

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 IP3-01-2019: Intelligent asset management finalisation

EXPECTED IMPACT

Actions will contribute to achieve an increase of the attractiveness and competitiveness of the railway transport in Europe through an efficient, safe, intelligent infrastructure maintenance approach. Expected specific impacts for work stream 1 are:

- improvement workers safety and working conditions;
- Cost reduction of the working methods by improving time needed (up to 20% reduction compared to state-of-the art methods);
- Improved quality, higher accuracy, of the results produced by the improved working method.

For work stream 2:

- improvement workers working conditions and safety;
- reduction of physical, static load;
- Sustainable employability of employees.

Type of Action: Research and Innovation Action (RIA)

4.2.9 S2R-OC-IP4-01-2020: Supporting the implementation of the IP4 ecosystem

SPECIFIC CHALLENGE

IP4 is defining a consistent bench of services covering all the steps of multi-modal journeys and providing a seamless passenger's experience. A long term CFM project (COHESIVE) started in 2017 is consolidating incrementally the various building blocks developed in the IP4 projects and then demonstrating the added value of the IP4 developments[61]. To be effective and to pave the way of an easy deployment, these demonstrations must take into account the constraints of a real environment. The specific challenge of this Open Call aims to provide this environment, and requires the following steps:

- Define relevant use-cases together with the CFM project members
- Provide real data supporting the implementation of the use-cases
- Clarify the adequate business rules needed to implement these use-cases
- Support when requested -in the field- demonstrations
- Collect the needs and expectations of future users of the solutions in order for Travel Service Providers to manage the offer of the travelers.

SCOPE

The action addresses the "non-technical" part of the ITD4.7 in the S2R MAAP. The overall integration of a great number of travel services and modes all over IP4 is the only way to demonstrate added

[61] https://shift2rail.org/research-development/ip4/

value on the market. The technical part (complex software integration) of ITD4.7 is developed by the CFM project COHESIVE, but performing relevant demonstrations require the involvement of additional stakeholders, for instance operators (urban rail, main line, other modes), transport authorities, cities, retailers, airlines.

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

- Provide real data in an operational environment.
- The consortium should include operators covering a large set of transport modes both public and private ones (e.g. railway, car, bike, electric scooter share).). It should also include public transport operators willing to test the functionalities provided by IP4.
- Complement by other actors providing services related to transport that could be offered integrated to improve travellers' experience (e.g. hotels, tourist info).
- Integrate small operators (e.g. small taxi companies, buses like school-bus companies, hotel shuttle services) by using SaaS technology developed in S2R-CFM-IP4-01-2020.
- Define a clear interface and demos implementation plan in coordination with the CFM project COHESIVE which will allow the alingement of the IP4 dissemination activities.

The demonstrations will run the IP4 developments in real corridor, and will prepare the IP4 eco-system deployment and market uptake.

The action will support IP4 to identify in concrete terms the requirements of the context in which the solutions are used.

At least three demonstration sites need to be provided:

1. Urban demo site, including
    a. Public transport (e.g. underground, tram, bus)
    b. Sharing modes (e.g. car, bike and scooter sharing)
2. Rural demo site, including
    a. Public transport (e.g. suburban trains and buses)
    b. Private modes (e.g. own car and ride sharing)
    c. Demand responsive transport

In addition a connection between the demo sites by long distance transport (e.g. rail, air[62], coach) should be showcased. The demonstration should cover at least 3 different countries, a retailer (e.g. MaaS operator), 5 different operators (including long distance operators both rail and coach and personel transport) and at least 2 small Public Transport Operators (PTOs).

Moreover, and based on sociological studies, the project will collect the needs and expectations of future users of the solutions in order for Travel Service Providers to tailor their offers to the travelers. Special attention should be given to special user groups (such as school children) exclusion aspects such as the effect digital divide, ageing, or physical or cognitive impairments that as a whole cover a significant part of the population that still need to access public transportation as smoothly and hassle free as possible.

The project is expected to reach TRL 6/7 by the end of the project.

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.

[62] Services will be provided by S2R through the CFM project partners.

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 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-IP4-01-2020: Enhanced end-user centric travel ecosystem.

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

- CONNECTIVE (GA 777522)
- COHESIVE (GA 777599)

EXPECTED IMPACT

The action, supporting the COHESIVE demonstration project, will bring the following impacts:

- Enrich the content of the demonstrations, by using real data, real processes, and potentially real environment for the demonstration
- Demonstrate that the IP4 eco-system is versatile, able to face diverse environment, business rules, transport modes, and data standards
- By bringing various stakeholders defining adequately the use-cases, the action will ease the market acceptance
- The action will create the conditions of a successful deployment of the IP4 solutions.

Type of Action: Innovation Action (IA)

4.2.10 S2R-OC-CCA-01-2020: Noise and Vibration Call

SPECIFIC CHALLENGE

Noise and vibration (N&V) represent one of the biggest environmental challenges for the railway. The target of this work area is to reduce the exposure to noise and vibration related to the railway sector in Europe. Population in the vicinity of railways no longer accepts the increasing N&V annoyance while on the other hand a shift to rail-traffic is important for environmental reasons. To address these issues, an Open Call consortium shall work complementary to the Member consortium. The Member consortium contains numerous European railway undertakings and manufacturers.

Ground vibrations from passing trains is an ongoing issue for the railway system in parallel to noise exposure. There is great need to develop a commonly accepted, practical and validated prediction tool for ground vibration impact studies. Open points include the quality of predictions depending today on the experience of the engineering company in charge since results are often based on the companies' experimental data. Furthermore, results should be presented with visualisation similar to noise mappings and ensure transferability depending on track as well as vehicle parameters. It must be ensured that the developed programme is also commercially distributed and supported after completion of the project.

New technologies for auralisation and visualisation of noise scenarios is an upcoming area for development. The technology offers the possibility of listening and experiencing visually the noise of trains passing a certain track, long before it is built. This is very important for project communications during planning phase of new or upgraded lines to increase the acceptance of new railways in Europe. A second use case is to demonstrate noise mitigation effects on innovative mitigation measures in most realistic virtual surrounding. In addition, it is of value to assess interior noise on new rolling stock as well using the same basic methods.

SCOPE

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

Work-stream 1: Ground Vibration

The objective of this work-stream is to develop a commonly accepted, practical and validated prediction tool for ground vibration impact studies during environmental impact assessment of new or upgraded railway projects. In addition, a track independent vehicle indicator (ground borne noise friendly vehicle) shall be investigated.

The activities in this work-stream are expected to focus on the following areas

1) Development of a frequency-based simulation and vibration prediction tool allowing to include a data base of typical emission and transmission spectra for different train (high speed, urban/suburban, regional, and freight train platforms), track and ground parameters and building types. The requirement specification for the model development should be based on input from the complementary project S2R-CFM-CCA-01-2019 and shall consider further development of state-of-the-art

approaches. Knowledge and experience from approaches used in former EU projects as RIVAS[63] and CARGOVIBES[64] is required for this task.

2) Development of models for the transposition of vibration emission data from one site to another including at least the influence of:
   - different tracks;
   - different substructures and ground conditions;
   - speed variations of trains.

   The consortium shall provide measurements if needed for the model development.

3) Application of a user-friendly graphical user interface for the usage of the simulation and prediction tool preferable with interfaces to commercial geographical information system (GIS) based software for noise- and general environmental impact studies.

4) Approval testing:
   - Testing of correctness to ensure that the program complies with the specifications. Validation of the final results of the models will be done by the complementary S2R-CFM-CCA-01-2019 project.

5) Documentation of the tool and the calculation models:
   - User handbook;
   - Documentation of all input and output interfaces;
   - Description and documentation of the calculation models and their functions.

The simulation and prediction tool shall include the different models (e.g. for speed correction functions, different train and track types etc.) developed during the project for the transposition of vibration emission data. Hybrid models shall be applied, which allow change between full calculation of transfer-functions, input of measured or databased data.

In addition, the tool shall provide input for vehicle specific parameters such as primary and secondary stiffness, mass and resilient wheels to identify influencing factors.

The tool shall provide enough open interfaces to be used for further improvements or integration of country specific particularities e.g. different standards or evaluation schemes or descriptors as well introducing mitigation measures.

. The project is expected to reach TRL 5 by the end of the project.

The above work-stream 1 activities are expected to account indicatively for about 70% of the action costs.

An indicative scheduling of the deliverables for work-stream 1 is suggested below[65] :

- State of the art, concept of software/tool M6
- Collection of vibration and ground database M12
- Software/tool M20

[63] http://www.rivas-project.eu/index.php?id=9

[64] https://cordis.europa.eu/project/rcn/98519/results/en

[65] 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

- Validation (approval testing) and uncertainties M22

Work-stream 2: New Technologies Auralisation and Visualisation

The objective of this work-stream is the development of a fully functional system for auralisation and visualisation based on physically correct synthesized railway noise and interfaces to a virtual reality visualisation software.

The activities in this work-stream are expected to focus on the following:

Develop an auralisation and visualisation ready-to-use software in agreement with the existing requirement document (FINE1 D9.1 – Requirements for Auralisation and Visualisation[66]) including both exterior and interior noise. The tool shall be able to meet three basic main requirements:

i. Demonstration of the results of the work on noise reduction in the S2R JU.
ii. Demonstration of vehicle performance for customers and development engineers.
iii. Demonstration of the acoustic situation and the effect of noise mitigation measures in large-scale projects preferable with an interface to commercial 3D Visualisation software.

The main part of the work shall be focused on exterior railway noise auralisation. For the visualisation an already existing software with integrated, usable audio interface shall be used. The audio interfaces shall be able to fully integrate and render the synthesized railway noise generation in high-quality and in accordance with the defined requirements and the proposed A&V technology coming from past projects such as FINE1 requirements (D9.1 Requirements for Auralisation and Visualisation[67]) and DESTINATE (D3.2 Demonstration of railway noise auralisation and visualisation[68]).

The functionality of the software is to be demonstrated using at least three examples of railway scenarios and shall include a database with different typical noise mitigation measures like sound barrier walls in different heights or distances, rail dampers etc (see FINE1-Deliverable 9.1) for different observation points under free combinations selected and adapted by the user. The initial interior noise auralisation can be measurement based: The auralisation shall at least enable interior source positioning, level- selection/adjustment of the measured sound, distance depending level perception).

The software development shall follow requirements proposed by the complementary project S2R-CFM-CCA-01-2019 which are expected to be available the first quarter of 2021.

Knowledge and experience of the FINE 1 and DESTINATE approaches as well as state of the art of Auralisation and Visualisation effects based on synthesized sound generation and virtual reality techniques are required.

The exploitation plan shall elaborate how this combined A&V-tool (as such complete) could be further developed in the future to be used as a commercial tool/integrated module in commercial auralisation and visualisation software.

The project is expected to reach TRL 5 by the end of the project.

The above work-stream 2 activities are expected to account indicatively for about 30% of the action costs

[66] Available for download here : https://projects.shift2rail.org/s2r_ipcc_n.aspx?p=FINE%201
[67] https://projects.shift2rail.org/s2r_ipcc_n.aspx?p=FINE%201#
[68] https://projects.shift2rail.org/s2r_ipCC_n.aspx?p=destinate

An indicative scheduling of the deliverables for work-stream 1 is suggested below[69] :

- a) Base-Version Exterior Noise M6
- b) User-Test-Version M12
- c) Final-User-Version M23

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 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-CCA-01-2019: Integrated mobility management (I2M), Energy and Noise & Vibration

.

EXPECTED IMPACT:

Ground Vibration:

Improvement of the planning process of new lines or the upgrade of existing lines by a common accepted model for impact studies on ground vibrations. The model will help to evaluate construction projects on their dedicated impact of ground vibration immission for citizens effected by railway vibration near to the tracks.

New Technologies - Auralisation and Visualisation (A&V)
Access to a fully functional software for Auralisation and Visualisation allowing the possibility of listening and experiencing visually the noise of trains passing a certain track, long before it is built and test different noise mitigation measures as well as assess modification of the interior noise. The synthesized noise is based on physically correct noise generation mechanisms. The A&V tools shall be used to enable a clear communication and conscious and knowing decision making by demonstrating the planned railway vehicle or railway project not only visual but also acoustically real and thus more concretely and convincingly.

Type of Action: Research and Innovation Action (RIA)

[69] 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

4.2.11 S2R-OC-IPX-01-2020: Innovation in guided transport

SPECIFIC CHALLENGE

Since the the modern hyperloop proof of concept was coined in a white paper in 2013, and with the creation of Shift2Rail in 2014, many activities touching innovation in guided transport have arisen in Europe and elsewhere in the world. Technologies dealing with innovative control systems for vehicle to vehicle interaction, with communication and positioning systems (incl. in tunnel environments), advanced magnetic levitation, with innovative light materials, with energy storage and regeneration solutions have been investigated in a fragmented and competitive manner. The challenge is to channel all these disperse innovations and technical solutions in a coherent framework that would potentially support a possible European implementation or migration of concepts towards other innovations in guided transport modes and to support interoperability with the Single European Railway Area (SERA).

SCOPE

In order to address the challenges described above, proposals should aim to create under the umbrella of Shift2Rail a framework, where innovation in guided transport would converge in the view of safe operation of the future systems.

This activity would need to be able to gather all promoters, at least European, of technologies around hyperloop and together (but not necessarily limited to these two points):

- Define the enhanced / innovative modes in terms of:
    - Concept of operations
    - Safety cases
    - Functional specification
    - Operational conditions and testing methodologies / environment.
- Identify the potential transferability and synergies with Railways solutions, processes and procedures in general, and in particular from a technological perspective with the S2R innovations (Technology Demonstrators and IPx activities).

EXPECTED IMPACT:

The expected impacts derive from gathering all relevant stakeholders around a common encompassing activity on innovative concepts for guided transport modes. The outcome of this activity should provide to the interested stakeholders the clarity on operational concepts and standardisation possibilities and also enable a structured discussion with policy-markers around safety/security and transport system(s) integration at European level.

Other expected impacts from these activities will be cross-fertilization of knowledge from other disciplines or from disruptive technologies and innovation (e.g. coming from hyperloop) not yet fully applicable to rail, which will encourage the exploration of innovative and unconventional ideas and research directions in guided transport modes.

Type of Action: Coordination and Support Action (CSA)

4.3 ANNEX III – Indicators and Scoreboard of KPIs

4.3.1 TABLE I - Horizon 2020 Key Performance Indicators[70] common to all JTI JUs

	Correspondence to general Annex 1	Key Performance Indicator	Definition/Responding to question	Type of data required	Data to be provided by	Baseline at the start of H2020 (latest available)	Target at the end of H2020	Automated
INDUSTRIAL LEADERSHIP	12	SME - Share of participating SMEs introducing innovations new to the company or the market (covering the period of the project plus three years);	Based on Community Innovation Survey (?). Number and % of participating SMEs that have introduced innovations to the company or to the market;	Number of SMEs that have introduced innovations;	H2020 beneficiaries through project reporting	n.a. [new approach under H2020]	50%	Yes
	13	SME - Growth and job creation in participating SMEs	Turnover of company, number of employees	Turnover of company, number of employees;	H2020 beneficiaries through project reporting	n.a. [new approach under H2020]	to be developed based on FP7 ex-post evaluation and /or first H2020 project results	Yes
SOCIETAL CHALENGES	14	Publications in peer-reviewed high impact journals in the area of the JTI	The percentage of papers published in the top 10% impact ranked journals by subject category.	Publications from relevant funded projects (DOI: Digital Object Identifiers); Journal impact benchmark (ranking) data to be collected by commercially available bibliometric databases.	H2020 beneficiaries through project reporting; Responsible Directorate/Service (via access to appropriate bibliometric databases)	n.a. [new approach under H2020]	[On average, 20 publications per €10 million funding (for	Yes

[70] (based on Annex II to Council Decision 2013/743/EU)

	Correspondence to general Annex 1	Key Performance Indicator	Definition/Responding to question	Type of data required	Data to be provided by	Baseline at the start of H2020 (latest available)	Target at the end of H2020	Automated
							all societal challenges)]	
	15	Patent applications and patents awarded in the area of the JTI	Number of patent applications by theme; Number of awarded patents by theme	Patent application number	H2020 beneficiaries through project reporting; Responsible Directorate/Service (via worldwide search engines such as ESPACENET, WOPI)	n.a. [new approach under H2020]	On average, 2 per €10 million funding (2014 - 2020) RTD A6	Yes
	16	Number of prototypes testing activities and clinical trials[71]	Number of prototypes, testing (feasibility/demo) activities, clinical trials	Reports on prototypes, and testing activities, clinical trials	H2020 beneficiaries through project reporting	n.a. [new approach under H2020]	[To be developed on the basis of first Horizon 2020 results]	Yes
	17	Number of joint public-private publications in projects	Number and share of joint public-private publications out of all relevant publications.	Properly flagged publications data (DOI) from relevant funded projects	H2020 beneficiaries through project reporting; Responsible Directorate/Service (via DOI and manual data input-flags)	n.a. [new approach under H2020]	[To be developed on the basis of first Horizon 2020 results]	Yes
	18*	New products, processes, and methods launched into the market	Number of projects with new innovative products, processes, instruments, methods, technologies	Project count and drop down list allowing to choose the type processes, products, instruments, methods, technologies	H2020 beneficiaries through project reporting	n.a. [new approach under H2020]	[To be developed on the basis of first Horizon 2020 results]	Yes

[71] Clinical trials are IMI specific

	Correspondence to general Annex 1	Key Performance Indicator	Definition/Responding to question	Type of data required	Data to be provided by	Baseline at the start of H2020 (latest available)	Target at the end of H2020	Automated
EVALUATION	NA	Time to inform (average time in days) all applicants of the outcome of the evaluation of their application from the final date for submission of completed proposals	To provide applicants with high quality and timely evaluation results and feedback after each evaluation step by implementing and monitoring a high scientific level peer reviewed process	Number of days (average)	Joint Undertaking	FP7 latest know results		Yes
	NA	Time to inform (average time in days) successful applicants of the outcome of the evaluation of their application from the final date for submission of completed proposals		Number of days (average)	Joint Undertaking	FP7 latest know results		Yes
	NA	Redress after evaluations	To provide applicants with high quality and timely evaluation results and feedback after each evaluation step by implementing and monitoring a high scientific level peer reviewed process	Number of redresses requested	Joint Undertaking	FP7 latest know results		
GRANTS	NA	Time to grant measured (average) from call deadline to signature of grants	To minimise the duration of the granting process aiming at ensuring a prompt implementation of the Grant Agreements through a simple and transparent grant preparation process	Cumulatively in days Average under H2020 (days) TTG < 270 days (as %of GAs signed)	Joint Undertaking (automatized)	n.a. [new approach under H2020]		Yes
	NA	Time for signing grant agreements from the date of informing successful applicants (average values)		Average under H2020 (days)	Joint Undertaking	n.a. [new approach under H2020]		Yes

	Correspondence to general Annex 1	Key Performance Indicator	Definition/Responding to question	Type of data required	Data to be provided by	Baseline at the start of H2020 (latest available)	Target at the end of H2020	Automated
AUDITS	NA	Error rate		% of common representative error; % residual error	CAS	n.a. [new approach under H2020]		Yes
	NA	Implementation of ex-post audit results		Number of cases implemented; in total €million; ´of cases implemented/total cases	CAS	n.a. [new approach under H2020]		Yes
PAYMENTS	NA	Time to pay (% made on time) -pre-financing - interim payment -final payment	To optimize the payments circuits, both operational and administrative, including payments to experts	Average number of days for Grants pre-financing, interim payments and final payments; Average number of days for administrative payments; Number of experts appointed	Joint Undertaking	FP7 latest know results	-pre-financing (30 days) - interim payment (90 days) -final payment ((90days)	Yes
HR	NA	Vacancy rate (%)		% of post filled in, composition of the JU staff [72]	Joint Undertaking	n.a. [new approach under H2020]		
JU EFFICIENCY	NA	Budget implementation/execution: 1. % CA to total budget 2. % PA to total budget	realistic yearly budget proposal, possibility to monitor and report on its execution, both in commitment (CA) and payments (PA), in line with sound financial management principle	% of CA and PA	Joint Undertaking		100% in CA and PA	Yes

[72] Additional indicators can be proposed/discussed with R.1 and/or DG HR

	Correspondence to general Annex 1	Key Performance Indicator	Definition/Responding to question	Type of data required	Data to be provided by	Baseline at the start of H2020 (latest available)	Target at the end of H2020	Automated
	NA	Administrative Budget: Number and % of total of late payments	realistic yearly budget proposal, possibility to monitor and report on its execution in line with sound financial management principle	Number of delayed payments % of delayed payments (of the total)	Joint Undertaking			Yes

NOTES:

18* This indicator is not a legally compulsory one, but it covers several additional specific indicators requested for more societal challenges by the services in charge.

4.3.2 TABLE II - Indicators for monitoring H2020 Cross-Cutting Issues[73] common to all JTI JUs

Correspondence in the general Annex 2	Cross-cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated
2	Widening the participation	2.1 Total number of participations by EU-28 Member State	Nationality of H2020 applicants & beneficiaries (number of)	H2020 applicants & beneficiaries at the submission and grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes
		2.2 Total amount of EU financial contribution by EU-28 Member State (EUR millions)	Nationality of H2020 beneficiaries and corresponding EU financial contribution	H2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes
NA		Total number of participations by Associated Countries	Nationality of H2020 applicants & beneficiaries (number of)	H2020 applicants & beneficiaries at the submission and grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes
NA		Total amount of EU financial contribution by Candidate Country (EUR millions)	Nationality of H2020 beneficiaries and corresponding EU financial contribution	H2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes

[73] (based on Annex III to Council Decision 2013/743/EU)

Correspondence in the general Annex 2	Cross-cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated
3	SMEs participation	3.1 Share of EU financial contribution going to SMEs (Enabling & industrial tech and Part III of Horizon 2020)	Number of H2020 beneficiaries flagged as SME; % of EU contribution going to beneficiaries flagged as SME	H2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report		Yes
6	Gender	6.1 Percentage of women participants in H2020 projects	Gender of participants in H2020 projects	H2020 Beneficiaries through project reporting		YES	Yes
		6.2 Percentage of women project coordinators in H2020	Gender of MSC fellows, ERC principle investigators and scientific coordinators in other H2020 activities	H2020 beneficiaries at the grant agreement signature stage		YES	Yes
		6.3 Percentage of women in EC advisory groups, expert groups, evaluation panels, individual experts, etc.	Gender of memberships in advisory groups, panels, etc.	Compiled by Responsible Directorate/ Service /Joint Undertaking based on existing administrative data made available by the CSC		YES	
7	International cooperation	7.1 Share of third-country participants in Horizon 2020	Nationality of H2020 beneficiaries	H2020 beneficiaries at the grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes
		7.2 Percentage of EU financial contribution attributed to third country participants	Nationality of H2020 beneficiaries and corresponding EU financial contribution	H2020 beneficiaries at the grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes

Correspondence in the general Annex 2	Cross-cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated
9	Bridging from discovery to market [74]	9.1 Share of projects and EU financial contribution allocated to Innovation Actions (IAs)	Number of IA projects	Project Office – at GA signature stage he/she will be required to flag on SYGMA. Responsible Directorate/Service (WP coordinator)/Joint Undertaking - via tool CCM2	JU AAR RTD Monitoring Report		Yes
		9.2 Within the innovation actions, share of EU financial contribution focussed on demonstration and first-of-a-kind activities	Topics properly flagged in the WP; follow-up at grant level	Responsible Directorate/Service (WP coordinator)/Joint Undertaking - via tool CCM2	JU AAR RTD Monitoring Report		Yes
NA		Scale of impact of projects (High Technology Readiness Level)	Number of projects addressing TRL[75] between…(4-6, 5-7)?	Joint Undertaking	JU AAR RTD Monitoring Report		
11	Private sector participation	11.1 Percentage of H2020 beneficiaries from the private for profit sector	Number of and % of the total H2020 beneficiaries classified by type of activity and legal status	H2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report		Yes
		11.2 Share of EU financial contribution going to private for profit entities (Enabling & industrial tech and Part III of Horizon 2020)	H2020 beneficiaries classified by type of activity; corresponding EU contribution	H2020 beneficiaries at grant agreement signature stage	JU AAR RTD Monitoring Report		Yes

[74] This indicator (9.2) is initially intended to monitor the Digital Agenda (its applicability could be only partial)

[75] TRL: Technology Readiness Level

Correspondence in the general Annex 2	Cross-cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated
12	Funding for PPPs	12.1 EU financial contribution for PPP (Art 187)	EU contribution to PPP (Art 187)	Responsible Directorate/Service	JU AAR RTD Monitoring Report		Yes
		12.2 PPPs leverage: total amount of funds leveraged through Art. 187 initiatives, including additional activities, divided by the EU contribution	Total funding made by private actors involved in PPPs - in-kind contribution already committed by private members in project selected for funding - additional activities (i.e. research expenditures/investment of industry in the sector, compared to previous year)	Joint Undertaking Services	JU AAR RTD Monitoring Report		
13	Communication and dissemination	13.3 Dissemination and outreach activities other than peer-reviewed publications - [Conferences, workshops, press releases, publications, flyers, exhibitions, trainings, social media, web-sites, communication campaigns (e.g radio, TV)]	A drop down list allows to choose the type of dissemination activity. Number of events, funding amount and number of persons reached thanks to the dissemination activities	H2020 Beneficiaries through project reporting	JU AAR RTD Monitoring Report	YES	Yes
14	Participation patterns of independent experts	14.2 Proposal evaluators by country	Nationality of proposal evaluators	Responsible Directorate /Service/Joint Undertaking in charge with the management of proposal evaluation			
		14.3 Proposal evaluators by organisations' type of activity	Type of activity of evaluators' organisations	Responsible Directorate /Service/Joint Undertaking in charge		YES	

Correspondence in the general Annex 2	Cross-cutting issue	Definition/Responding to question	Type of data required	Data to be provided by	Data to be provided in/to	Direct contribution to ERA	Automated
				with the management of proposal evaluation			
NA	Participation of RTOs and Universities	Participation of RTO[76]s and Universities in PPPs (Art 187 initiatives)	Number of participations of RTOs to funded projects and % of the total Number of participations of Universities to funded projects and % of the total % of budget allocated to RTOs and to Universities	H2020 beneficiaries at the grant agreement signature stage	JU AAR RTD Monitoring Report	YES	Yes
NA	Ethics	The objective is ensuring that research projects funded are compliant with provisions on ethics efficiently	% of proposals not granted because non-compliance with ethical rules/proposals invited do grant (target 0%); time to ethics clearance 5target 45 days)[77]	Responsible Directorate /Service/Joint Undertaking	JU AAR RTD Monitoring Report		

Notes:

*H2020 applicants - all those who submitted H2020 proposals

*H2020 beneficiaries - all those who have signed a H2020 Grant Agreement

*Responsible Directorate - DG RTD Directorates and R&I DGs family in charge with management of H2020 activities *Services - Executive Agencies and other external bodies in charge with H2020 activities

*Project officer - is in charge of managing H2020 projects in Responsible Directorate/Service including Executive Agencies

[76] RTO: Research and Technology Organisation

[77] Data relates to pre-granting ethics review. This time span runs in parallel to granting process.

4.3.3 TABLE III - Key Performance Indicators specific for the S2R JU

#	Key Performance Indicator	Objective	Data to be provided by	Baseline at the start of H2020	Target at the end of H2020	Automated
S2R						
1	% reduction in the costs of developing, maintaining, operating and renewing infrastructure and rolling stock and increase energy efficiency compared to "State-of-the-art"	Reduce the life-cycle cost of the railway transport system	JU	"State-of-the-art" 2014	> 50 %	No
2	% increase the capacity of railway segments to meet increased demand for passenger and freight railway services compared to "State-of-the-art" 2014	Enhance the capacity of the railway transport system	JU	"State-of-the-art" 2014	100%	No
3	% decrease in unreliability and late arrivals compared to "State-of-the-art" 2014	Increase in the quality of rail services	JU	"State-of-the-art" 2014	> 50%	No
4	Reduce noise emissions and vibrations linked to rolling stock and respectively infrastructure compared to "State-of-the-art" 2014	Reduce the negative externalities linked to railway transport	JU	"State-of-the-art" 2014	> 3 - 10 dBA	No
5	Addressing open points in TSIs, compared to "State-of-the-art" 2014	Enhance interoperability of the railway system	JU	"State-of-the-art" 2014		No

#	Key Performance Indicator	Objective	Data to be provided by	Baseline at the start of H2020	Target at the end of H2020	Automated
6	Number of Integrated Technology Demonstrators (ITDs) and System Platform demonstrations	Improve market uptake of innovative railway solutions through large-scale demonstration activities	JU	tbd in the Multi-Annual Action Plan		Yes
7	Share of the fund allocated to the different Innovation Programmes and to cross-cutting themes	Ensure that funding covers the railway system as a whole	JU	n.a.	> 80%	No
8	Percentage of topics resulting in signature of GA	Ensure a sufficiently high call topics success rate	JU	n.a.	> 90%	Yes
9	% of resources consumption versus plan (members only)	WP execution by members - resources	JU	n.a.	> 80%	Yes
10	% of deliverables available versus plan (members only)	WP execution by members - deliverables	JU	n.a.	> 80%	Yes

4.3.4 TABLE IV – Initial estimation of Release 2.0 - of the Key Performance Indicators of the Shift2Rail Programme

SPD	LCC		Capacity		Punctuality		S2R KPIs
Target	-50%		+100%		+50%		
High speed	-15%	-18%	69%	74%	29%	19%	
Regional	-21%	-24%	57%	49%	51%	15%	
Urban	-16%	-18%	23%	28%	n / a		
Freight	-39%	-40%	42%-114%*	91%	78%	71%	

*depending on IP2 improvement 0-50%

release 1.0

4.4 ANNEX IV – List of Members of S2R JU other than the Union

NAME OF MEMBER	CONSTITUENT ENTITIES OF CONSORTIA	COUNTRY
AERFITEC Consortium	*AERNNOVA AEROSPACE S.A.U.*	ES
	FIDAMC	ES
	FUNDACION TECNALIA RESEARCH & INNOVATION	ES
ALSTOM Transport SA		FR
Amadeus IT Group SA		ES
Hitachi Rail STS S.p.A.		IT
AZD Praha s.r.o.		CZ
Bombardier Transportation GmbH		DE
Competitive Freight Wagon Consortium (CFW)	*Contraffic GmbH*	DE
	Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)	DE
	Waggonbau Niesky GmbH	DE
	Centro de Estudios e Investigaciones Técnicas (CEIT)	ES
	Verband der Bahnindustrie in Deutschland (VDB)	DE
Construcciones y Auxiliar de Ferrocarriles		ES
Deutsche Bahn AG		DE
DIGINEXT		FR
EUropean Rail Operating community Consortium (EUROC)	*Infraestruturas de Portugal, S.A.*	PT
	BLS AG	CH
	CP	PT
	Finnish Transport Agency	FI
	ÖBB-Infrastruktur AG	AT

NAME OF MEMBER	CONSTITUENT ENTITIES OF CONSORTIA	COUNTRY
	Polskie Koleje Państwowe S.A. (PKP)	PL
	PRORAIL B.V.	NL
	Schweizerische Bundesbahnen (SBB)	CH
	Slovenske zeleznice (SZ)	SI
	Türkiye Cumhuriyeti Devlet Demiryollari (TCDD)	TR
Faiveley Transport		FR
HaCon Ingenieurgesellschaft mbH		DE
INDRA SISTEMAS S.A.		ES
Kontron Transportation Austria AG		AT
Knorr-Bremse Systems für Schienenfahrzeuge GmbH		DE
MER MEC S.p.A		IT
Network Rail Infrastructure Limited		UK
Siemens Aktiengesellschaft		DE
Smart DeMain (SDM) consortium	*Strukton Rail BV*	NL
	ACCIONA INFRAESTRUCTURAS SA	ES
	Deutsches Zenttrum für Luft-und Raumfahrt e.V. (DLR)	DE
	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.	DE
	Centro de Estudios de Materiales y Control de Obra S.A	ES
Smart Rail Control (SmartRaCon) consortium	*Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)*	DE
	Centro de Estudios e Investigaciones Técnicas (CEIT)	ES
	FONDATION DE COOPERATION SCIENTIFIQUE RAILENIUM	FR

NAME OF MEMBER	CONSTITUENT ENTITIES OF CONSORTIA	COUNTRY
	Nottingham Scientific Ltd	UK
Société Nationale des Chemins de Fer Français Mobilités (SNCF Mobilités)		FR
Swi'Tracken consortium	*FONDATION DE COOPERATION SCIENTIFIQUE RAILENIUM*	FR
	UNIVERSIDADE DO PORTO	PT
	TATASTEEL	FR
	UNIVERSIDAD DEL PAIS VASCO	ES
	UNIVERSIDADE DO MINHO	PT
	VOSSLOH-COGIFER	FR
	INSTITUT FÜR ZUKUNFTSSTUDIEN UND TECHNOLOGIEBEWERTUNG	DE
	EGIS RAIL	FR
	GROUPE EUROTUNNEL SA	FR
	TRONICO ALCEN	FR
Patentes Talgo S.L.U.		ES
THALES		FR
Trafikverket		SE
Virtual Vehicle Austria consortium+ (VVAC+)	*Kompetenzzentrum - Das virtuelle Fahrzeug, Forschungsgesellschaft mbH (Virtual Vehicle)*	AT
	FCP Firtsch, Chiari & Partner ZT GmbH	AT
	Getzner Werkstoffe GmbH	AT
	Kirchdorfer Fertigteilholding GmbH	AT
	Plasser&Theurer GmbH	AT
	voestalpine Schienen GmbH	AT
	voestalpine VAE GmbH	AT
	Wiener Linien GmbH & Co KG	AT
	AVL List GmbH	AT

NAME OF MEMBER	CONSTITUENT ENTITIES OF CONSORTIA	COUNTRY
	PJM Messtechnik GmbH	AT
	TATRAVAGONKA a.s.	SK
	AC2T research GmbH	AT
	Materials Center Leoben Forschung GmbH	AT