

WORK PROGRAMME 2022-2024

adopted by the EU-Rail Governing Board on 1 March 2022

In accordance with Council Regulation (EU) 2021/2085 and with Article 33 of the Europe's Rail Financial Rules S2R Decision n° 11/2019.

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

NOTICE RELATED TO S2R JU SUCCESSOR

On 30 November 2021, Council Regulation (EU) 2021/2085 of 19 November 2021, establishing the Joint Undertakings under Horizon Europe and repealing Regulations (EC) No 219/2007, (EU) No 557/2014, (EU) No 558/2014, (EU) No 559/2014, (EU) No 560/2014, (EU) No 561/2014 and (EU) No 642/2014, entered into force. In accordance with this Regulation, the Europe's Rail Joint Undertaking (EU-Rail) became the legal and universal successor in respect of all contracts, including employment contracts, procurement contracts and grant agreements, liabilities and acquired property of the Shift2Rail Joint Undertaking (S2R JU). Therefore, if reference is made to S2R JU's contracts/agreements/assets/liabilities in this Work Programme, they should be understood as those of EU-Rail's. In addition, in accordance with Article 174(12), at its first meeting on 21 December 2021, the Governing Board adopted Decision 2/2021 listing the decisions adopted by the Governing Board of S2R that shall continue to apply for Eu-Rail.

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym/ Abbreviation	Full Title
AAR	Annual Activity Report
ABAC	Accrual Based Accounting
AI	Artificial Intelligence
ATO	Automatic Train Operation
ATP	Automatic Train Protection
A&V	Auralisation and Visualisation
BEMU	Battery Electric Multiple Unit
BIM	Building Information Modelling
CA	Commitment Appropriation
CAPEX	Capital Expenditure
CBA	Cost Benefit Analysis
CBM	Condition-Based Maintenance
CBO	Common Back Office
CCA	Cross Cutting Activities
CCRCC	Control Command and Railway Communication Conference
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
CSA	Coordination and support action
CSIRT	Computer Security Incident Response Team
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
EU-Rail	Europe's Rail Joint Undertaking
FACTs	Flexible AC Transmission Systems
FFFIS	Form Fit Functional Interface Specifications

Acronym/ Abbreviation	Full Title
FIS	Functional Interface Specifications
FWC	Framework Contract
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
MAWP	Multi-Annual Work Plan
MB	Moving block
MFF	Multiannual Financial Framework
MoU	Memorandum of Understanding
MP	Master Plan
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

Acronym/ Abbreviation	Full Title
OPEX	Operational Expenditure
OTM	On Track Machine
PA	Payment Appropriation
PPP	Public-Private Partnership
PRM	Persons with Reduced Mobility
PTC	Positive Train Control
PTI	Platform Train Interface
PTO	Public Transport Operator
RAIM	Receiver Autonomous Integrity Monitoring
RAL	Unpaid amount
RAMS	Reliability and Maintainability System
RBC	Radio Block Centre
RCA	Reference Command Control and Signalling Architecture
R-CSIRT	Railway Computer Security Incident Response Team
RFID	Radio Frequency Identification
R&D	Research and Development
R&I	Research and Innovation
RIA	Research and Innovation Action
RoI	Return of Investment
RU	Railway Undertaking
S2R (JU)	Shift2Rail (Joint Undertaking)
SaaS	Software as a Service
SBA	Single Basic Act (Council Regulation No 2021/2085 establishing the Joint Undertakings under Horizon Europe)
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
SPSG	System Pillar steering group
SRG	States Representatives Group
SRIA	Strategic Research and Innovation Agenda
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

Acronym/ Abbreviation	Full Title
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
URID	User Requirements Working Group
V&V	Verification & Validation
WA	Work Area
WCRR	World Congress on Railway Research
WP	Work Programme

1. INTRODUCTION

The *Draft* Work Programme 2022-2024 (hereinafter the Work Programme) of the Europe's Rail Joint Undertaking (hereinafter EU-Rail) outlines

- the scope of the activities that will be performed in 2022 related to the launch of its new Research and Innovation (R&I) Programme governed by the Horizon Europe rules. The main focus will be the launched of the first series of calls for proposals and calls for tenders that should result in the start of research and innovation as from mid 2022 and full phase in by the end of 2022.
- as well as the R&I activities related to the projects launched in the previous years and the S2R Programme; the focus will be on the execution of the research and innovation activities previously signed and needed to advance in delivering the Technology Demonstrators, including for presenting them at InnoTrans 2022, and in view of reaching S2R Programme targets by 2024.

EU-Rail Programme aims at contributing to the ambitious targets of the “Sustainable and Smart Mobility Strategy” of the European Commission¹, building upon the many results already achieved and those still to be finalized of the ongoing S2R Programme, ensuring the adequate phase out and ramp up. To highlight the most relevant of these targets, digitalization and automation of railway systems should be mentioned, being a key path towards sustainable (climate neutral, life-cycle cost efficient, connected, integrated through a system approach) mobility for passengers and supply chain.

It also provides details on the corporate and supporting activities for the period to come and explains the governance structure of EU-Rail, including the tasks of individual bodies of the JU. Finally, the WP 2022-2024 AWP presents information on the 2022 Budget, as well as estimated figures for the following years up to 2024.

This Work Programme shall be read in conjunction with the EU-Rail's Master Plan (MP)² and Multi-Annual Work Plan (MAWP)³, both adopted on 1 March 2022 by the Governing Board (hereinafter also GB).

In the introductory part (Section 1), EU-Rail background, mission and the strategy for the implementation of the Programme are described. Section 2 outlines the operational activities planned for 2022, the corporate and supporting activities, the EU-Rail governance, as well as it provides information on the organisational management and internal control framework. Section 3 explains the EU-Rail's 2022-2024 Budget. Further information regarding IKAA, KPIs, demonstrators, organisational chart, as well as a full list of EU-Rail's Founding Members, is provided in Section 4.

1.1 The Europe's Rail Joint Undertaking (EU-Rail)

EU-Rail was established by the Council Regulation (EU) No 2021/2085 of 19 November 2021 establishing the Joint Undertakings under Horizon Europe and repealing Regulations (EC) No 219/2007, (EU) No 557/2014, (EU) No 558/2014, (EU) No 559/2014, (EU) No 560/2014, (EU) No

¹ COM(2020) 789 Final of 9 December 2020, https://eur-lex.europa.eu/resource.html?uri=cellar:5e601657-3b06-11eb-b27b-01aa75ed71a1.0001.02/DOC_1&format=PDF

²) Adopted by Governing Board Decision n° 01/2022 and available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

³ Adopted by Governing Board Decision n° 02/2022 and available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents>

561/2014 and (EU) No 642/2014 (hereinafter the Single Basic Act or SBA)⁴ which entered in force on 30 November 2021.

In accordance with Article 174(6) of the SBA, the EU-Rail is the legal and universal successor in respect of all contracts, including employment contracts and grant agreements, liabilities and acquired property of the S2R JU which it replaced and succeeded.

EU-Rail is as public-private partnership in the rail sector established under Article 187 of the Treaty on the Functioning of the European Union.

The objective of EU-Rail is to deliver a high capacity integrated European railway network by eliminating barriers to interoperability and providing solutions for full integration, covering traffic management, vehicles, infrastructure and services, aiming to achieve faster uptake and deployment of projects and innovations. That should exploit the huge potential for digitalisation and automation to reduce rail's costs, increase its capacity and enhance its flexibility and reliability, and should be based upon a solid reference functional system architecture shared by the sector, in coordination with the European Union Agency for Railways.

Building on advances in automation and digitalization, EU-Rail aims at speeding up researching, developing and deploying operational and technological innovative solutions to achieve the radical transformation of the rail system and deliver on European Green Deal objectives. These objectives include,

- a shift of a substantial part of the 75% of inland freight carried by road towards transport by rail and inland waterways,
- scheduled collective travel under 500 km should be carbon-neutral by 2030 within the EU.
- traffic on high-speed rail will double by 2030 and triple by 2050.
- rail freight traffic will increase by 50% by 2030 and double by 2050.
- a fully operational, multimodal Trans-European Transport Network (TEN-T) for sustainable and smart transport with high speed connectivity by 2050.
- improving the competitiveness of rail and supporting the European technological leadership in rail.

In addition to the General and Specific Objectives established in Chapter 1 of the SBA, EU-RAIL is entrusted with the following:

General Objectives

- (a) contribute towards the achievement of the Single European Railway Area;
- (b) ensure a fast transition to more attractive, user-friendly, competitive, affordable, easy to maintain, efficient and sustainable European rail system, integrated into the wider mobility system;
- (c) support the development of a strong and globally competitive European rail industry.

Specific objectives

- (a) facilitate research and innovation activities to deliver an integrated European railway network by design, eliminating barriers to interoperability and providing solutions for full integration, covering traffic management, vehicles, infrastructure also including integration with non-standard national gauges, such as 1520, 1000 or 1668 mm railway, and services, and providing the best answer to the needs of passengers and businesses, accelerating uptake of innovative

⁴ OJ L 427, 30.11.2021, p. 17–119

solutions to support the Single European Railway Area, while increasing capacity and reliability and decreasing costs of railway transport;

- (b) deliver a sustainable and resilient rail system: by developing a zero-emission, silent rail system and climate resilient infrastructure, applying circular economy to the rail sector, piloting the use of innovative processes, technologies, designs and materials in the full life-cycle of rail systems and developing other innovative solutions to guided surface transport;
- (c) develop through its System Pillar a unified operational concept and a functional, safe and secure system architecture, with due consideration of cyber-security aspects, focused on the European railway network to which Directive 2016/797 applies, for integrated European rail traffic management, command, control and signalling systems, including automated train operation which shall ensure that research and innovation is targeted on commonly agreed and shared customer requirements and operational needs, and is open to evolution;
- (d) facilitate research and innovation activities related to rail freight and intermodal transport services to deliver a competitive green rail freight fully integrated into the logistic value chain, with automation and digitalisation of freight rail at the core;
- (e) develop demonstration projects in interested member states;
- (f) contribute to the development of a strong and globally competitive European rail industry;
- (g) enable, promote and exploit synergies with other Union policies, programmes, initiatives, instruments or funds in order to maximise its impact and added value.

In carrying out its activities, the Europe's Rail Joint Undertaking shall seek a geographically balanced involvement of members and partners in its activities. It shall also establish the necessary international connections in relation to rail research and innovation, in line with the Commission priorities.

In addition to the tasks set out in Article 5 SBA, EU-Rail together with the Commission had to prepare and, after consultation of the states' representative group, submit for adoption by the Governing Board the Master Plan, developed in consultation with all relevant stakeholders in the railway system and rail supply industry.

In accordance with article 87(1) of the SBA, the members of EU-Rail are the Union, represented by the Commission, and 25 Founding Members listed in Annex II of the SBA⁵. As stated in article 6 of the SBA, in order to become members of EU-Rail, the Founding Members signed a letter of commitment detailing the scope of the membership in terms of content, activities and its duration, as well as the Founding Members' contributions to the joint undertaking, including an indication of the envisaged additional activities.

EU-Rail shall launch a call for Associated members to be selected in accordance with Article 7 of the SBA.

1.2 Mission statement of EU-Rail

Taking into consideration the objectives to be achieved the following vision and mission are established.

The vision of EU-Rail is

To deliver, via an integrated system approach, a high capacity, flexible, multi-modal, sustainable and reliable integrated European railway network by eliminating barriers to interoperability and providing solutions for full integration, for European citizens and cargo.

The Mission Statement of EU-Rail is

⁵ Please see Annex V of this Work Programme for full list of members other than the Union.

1.3 Background and link with the Master Plan

As defined in the SBA, the “Strategic Research and Innovation Agenda” (SRIA) represents the document covering the duration of Horizon Europe that identifies the key priorities and the essential technologies and innovations required to achieve the objectives of the JU.

In accordance with Article 86(5) SBA, the Master Plan shall constitute the EU-Rail Strategic Research and Innovation Agenda within the meaning of Article 2(12) SBA.

The Master Plan was developed in consultation with railway stakeholders. The draft was open for feedback to the general public via the JU’s website for 4 weeks and a webinar was organized on 19 November 2021. The Master Plan was sent in consultation to the Scientific Committee and the States Representatives Group, it has been presented to the Transport Working Party of the Council and the TRAN Committee of the European Parliament. Comments and suggestions received have been incorporated, when relevant, in the final version adopted by the EU-Rail Governing Board on 1 March 2022.

The EU-Rail’s Master Plan builds also upon the “Rail Strategic Research and Innovation Agenda”⁶ of the European Rail Research Advisory Council (ERRAC). ERRAC is a research platform composed of representatives from most of the major European railway research stakeholders: manufacturers, operators, infrastructure managers, the European Commission, EU Member States, academics and users’ groups. Its mission is to deliver a vision of the railway’s future enabled by Research and Innovation activities.

The Master Plan provides guidance for the Europe’s Rail Joint Undertaking’s more specific tasks, namely

- develop in its System Pillar a system view that reflects the needs of the rail manufacturing industry, the rail operating community, Member States and other rail private and public stakeholders, including bodies representing customers, such as passengers and freight and staff, as well as relevant actors outside the traditional rail sector.

The ‘system view’ shall encompass:

- the development of the operational concept and system architecture, including the definition of the services, functional blocks, and interfaces which form the basis of rail system operations;
- the development of associated specifications including interfaces, functional requirement specifications and system requirement specifications to feed into Technical Specifications for Interoperability (TSI) established pursuant to Directive (EU) 2016/797 or standardisation processes to lead to higher levels of digitalisation and automation;
- ensuring the system is maintained, error-corrected and able to adapt over time and ensure migration considerations from current architectures;

⁶ https://shift2rail.org/wp-content/uploads/2020/12/RAIL-Strategic-Research-and-Innovation-Agenda-2020-FINAL_dec2020.pdf

- ensuring that the necessary interfaces with other modes, as well as with metro and trams or light rail systems, are assessed and demonstrated, in particular for freight and passenger flows;
- facilitate the research and innovation activities necessary to achieve the objectives of EU-Rail, including low TRLs rail-focused research and innovation activities. In that respect, Eu-Rail shall:
 - define and organise the research, innovation, demonstration, validation and study activities to be carried out under its authority, while avoiding fragmentation of such activities;
 - exploit standardisation and modularity opportunities, and facilitate the interfaces with other modes and systems;
 - develop demonstration projects;
 - develop close cooperation and ensure coordination with related European, national and international research and innovation activities in the rail sector and beyond as necessary, in particular under Horizon Europe, thereby enabling the Europe's Rail Joint Undertaking to play a major role in rail-related research and innovation while also benefiting from scientific and technological advances reached in other sectors;
 - ensure, through the cooperation referred here above, the translation of research into effective development effort and development of pioneering innovations and ultimately into market focused innovation through demonstration and deployment;
 - perform any tasks necessary to achieve the objectives set out in Articles 4 and 85 SBA.

Five areas of priority for EU-Rail have been determined in its MP:

- 1) European rail traffic management and supporting rail's key role in a multimodal transport system
- 2) Digital and automated train operations
- 3) Sustainable and digital assets
- 4) Competitive digital green rail freight
- 5) Smart solutions for low density traffic lines (cost-efficient regional lines)

These priorities will be underpinned by a system view to ensure a harmonised approach to the evolution of the Single European Rail Area.

EU-Rail will also work on forward-looking activities, tackling disruptive technologies and thinking, through performing exploratory research and other complementary activities.

The JU will foster a close cooperation and ensure coordination with related European, national and international research and innovation activities in the rail sector and beyond as necessary, in particular under Horizon Europe, Connecting Europe, and the Digital Agenda. The regional dimension will be a priority to ensure that EU-Rail will deliver services to connect European regions in an integrated network approach.

EU-RAIL JU will put in place measures to maximise its impact using synergies with other European, national and regional programmes and activities. Beyond the involvement in the overall coordination of Horizon Europe.

This Work Programme results from extracting the priority research and innovation activities identified in the MP and detailed in the MAWP to be delivered by the end of 2026, considering the available budgetary resources in 2022, including under the multi-annuality by instalment principle and the SBA conditions.

1.4 Strategy for the implementation of the programme

The overall Strategy of EU-Rail is anchored in its Master Plan and is further elaborated in its Multi-Annual Work Plan.

In order to deliver its objectives and strategy, EU-Rail will be set-up around one single Research and Innovation Programme based on a system view. The Programme will be delivered by two integrated pillars - the System Pillar and the Innovation Pillar - and complemented by a Deployment Group, all together covering the full life cycle of R&I from blue sky to pre-deployment and pre-industrialisation processes, TRL 9.

The System Pillar activities

The purpose of the System Pillar is to introduce common EU railway system view so that the evolution of the rail system is based on common operational visions and a layered functional architecture. The idea of the System Pillar is integrating new scientific knowledge and other industry best practices in order to accelerate and better organise its evolution. The System Pillar will be the 'generic system integrator' for the EU-Rail and perform the role of architect of the future railway system. This means that the System Pillar would prepare and propose the concept of operations, the system architecture, the associated standards and specifications, and migration strategies.

The System Pillar *Task 1* will be to define the high-level overall railway architecture and operational concept for the EU Rail System. It will be focused on the European railway network to which Directive 2016/797 applies.

Task 2 of the System Pillar will be in the area of control-command and signalling (CCS). The regulation and implementation of European rail CCS is of central importance in the running of a safe, efficient, interoperable, robust and reliable rail service in Europe. CCS deals with all the on-board and trackside equipment required to ensure safety and to command and control movements of trains authorised to travel on the network. The task is to develop the operational concept(s) and functional system architecture for a genuine integrated European CCS system, supported by a model-based systems architecting & engineering approach, beyond the current specifications in the CCS Technical Specification for Interoperability, with much greater standardisation and much less variation than at present. This integrated CCS system shall on the one hand deliver unrestricted movement of trains, on the other hand, it shall create a single market for rail components. Task 2 will evolve and encompass relevant activities to answer other research and innovation areas of the Innovation Pillar, such as the Digital Automatic Coupling for rail freight.

The Innovation Pillar activities

The Innovation Pillar is set up to deliver user-focused research, innovation and large-scale demonstrations. It will deliver the operational and technological solutions which provide the necessary capabilities to transform the European rail system. Its activities are organised in seven Flagship Areas and the Transversal Topic, more details of which are presented in Section 2.3.1.

Continuous exchanges will exist between the System Pillar and Innovation Pillar activities as part of the Integrated R&I Programme, with a bi-directional flow: both pillars should provide input and output to each other against a clearly defined series of priorities and objectives to be achieved. In general, these objectives include the following:

- contribute towards the achievement of the Single European Railway Area;

- ensure a fast transition to more attractive, user-friendly, competitive, affordable, easy to maintain, efficient and sustainable European rail system, integrated into the wider mobility system;
- support the development of a strong and globally competitive European rail industry.

These general objectives can be further specified as follows:

- (a) facilitate research and innovation activities to deliver an integrated European railway network by design, eliminating barriers to interoperability and providing solutions for full integration, covering traffic management, vehicles, infrastructure also including integration with non-standard national gauges, such as 1520, 1000 or 1668 mm railway, and services, and providing the best answer to the needs of passengers and businesses, accelerating uptake of innovative solutions to support the Single European Railway Area, while increasing capacity and reliability and decreasing costs of railway transport;
- (b) deliver a sustainable and resilient rail system: by developing a zero-emission, silent rail system and climate resilient infrastructure, applying circular economy to the rail sector, piloting the use of innovative processes, technologies, designs and materials in the full life-cycle of rail systems and developing other innovative solutions to guided surface transport;
- (c) develop through its System Pillar a unified operational concept and a functional, safe and secure system architecture, with due consideration of cyber-security aspects, focused on the European railway network to which Directive 2016/797 applies, for integrated European rail traffic management, command, control and signalling systems, including automated train operation which shall ensure that research and innovation is targeted on commonly agreed and shared customer requirements and operational needs, and is open to evolution;
- (d) facilitate research and innovation activities related to rail freight and intermodal transport services to deliver a competitive green rail freight fully integrated into the logistic value chain, with automation and digitalisation of freight rail at the core;
- (e) develop demonstration projects in interested member states;
- (f) contribute to the development of a strong and globally competitive European rail industry;
- (g) enable, promote and exploit synergies with other Union policies, programmes, initiatives, instruments or funds in order to maximise its impact and added value.

The Deployment Group Activities

The Deployment Group should consist of European rail representatives, in particular of Infrastructure Managers and Rail Operators, but also of suppliers to ensure the preparedness of products, to advise the JU on the way coordinated and integrated deployment can be organised, in particular on the following elements to be proposed by the JU Executive Director, and in consultation with rail stakeholders (such as users associations, logistics associations, environment NGOs etc.), including a representative of the state representative group:

- (a) Examine and provide recommendations on alternative scenarios for the rollout of innovative solutions.
- (b) A roadmap for the coordinated and integrated deployment of the relevant rail research and innovation results, (incl. investment plan if needed).
- (c) Consideration of human factors as a result of deployment.
- (d) Assessment of the relevant legal framework, its necessary adaptations, and the options for the transition phase.
- (e) Ensure consideration of diversity of situations across the Union.
- (f) Alignment of deployment and investment plans.
- (g) Risks and opportunities associated to uncoordinated initiatives.
- (h) Phasing out of existing legacy systems and consideration on the necessary accompanying funding and financial measures.

- (i) Use of a performance scheme that would contribute to accelerating deployment and/or any other relevant measures.
- (j) Any other relevant matter that would contribute to reducing the innovation lifecycle and increase the performance of rail, maintaining the same level of safety or increasing it.

The activities of the Deployment Group are expected to start during the second part of 2022.

In 2022, the implementation of the above described R&I strategy will be in launched phases.

After the decision-making and advisory bodies of EU-Rail becoming fully operational, and after adopting the strategic documents such as the MP, MAWP and this Work Programme, the JU will focus its resources on the operational ramp up of the Programme. In particular:

- two calls for proposals are planned for 2022, a first one related to “Industrial Research” activities to be published in the first half of March, and a second one expected for Q3 2022, focused to “Exploratory Research and Other Activities”;
- the publication of a large procurement procedure to ramp up the activities of the System Pillar, setting up the core group, the pool of experts that will be performing the specific activities under Task 1 and 2 and, finally, the continuous support for the maintenance of the existing TSI specifications to prepare for the deployment of the EU-Rail innovative operational and technological solutions;
- ad hoc procurement procedures to avail the JU with the necessary expertise in relation to specific studies, analysis and assessment in relation to the core research and innovation activities.

The major challenges for the JU result from the need to

- consolidate EU-Rail structure, processes and organization in line with the provisions of the SBA, including in terms of back office arrangements, review of HE systems and processes, etc.,
- ensure that the first call's grant agreements are signed and project started by November 2022, which requires a timely processing of all relevant steps and the collaboration of all actors involved,
- ensure that the calls openness creates concrete opportunities for the integration of other rail stakeholders to join the Programme, in particular SMEs, Start ups, etc.
- set up the sound interaction between the System Pillar and Innovation Pillar, their respective governance and relevant change management processes, to set the basis for the delivery of results and their market uptake,
- explore non traditional and emerging guided land transport systems.

The risks identified in the following section identify mitigation actions that will be put in place to ensure the delivery of this first year of the Programme.

In parallel, the details of the implementation strategy, including the performance indicators for the Flagship Areas and the Transversal Topic, will be further elaborated during the year.

The topic that are included in the first call of the JU included in this Work Programme are considered critical to pursue the Master Plan research and innovation agenda and they require the following:

- Expertise from rail infrastructure managers and railway undertakings, which should allow
 - defining main challenges, use cases and functional needs,
 - specifying, prioritizing and clustering demonstrators to ensure that researched innovative processes, operational and technological solutions are covered,
 - hosting the demonstrations and providing test facilities,

- providing data structures and content as well as processes, e.g. certification which can be subject for digitalisation.
- Expertise from rail suppliers (system integrators, manufacturers and/or technology providers), which should allow, jointly,
 - proposing operational and technological innovative solutions to identified use cases and functional needs,
 - identifying the technical requirements and interface specifications, aligned with the System Pillar architecture,
 - designing, developing, prototyping and delivering innovative operational & technological solutions and systems to be integrated within the demonstrations, depending on the specific target TRL level.
- Expertise from research institutes and academia, which should allow
 - planning, developing, studying, testing and evaluating solutions, systems and demonstrators together with the previous categories of expertise,
 - supporting any possible scientific or methodological issues that may arise during the performance of the action
 - contributing to other aspects of the innovation cycle, as well as to the procedural aspects for validation, certification, etc..
- Complementary expertise from other sectors and parties, with particular attention to SMEs and Start-ups, which may contribute to enhance the actions' outcome.

The JU will monitor and report to the GB the involvement of the stakeholders in its different activities.

2. WORK PROGRAMME 2022

2.1 Message from the Executive Director

Message of the Europe's Rail Executive Director

This is the first Work Programme of Europe's Rail to implement the Union funding entrusted to the JU to deliver its vision and mission, as established in the SBA, with clear priority' areas identified in the Master Plan and finally detailed in a structured programme construed around flagship areas and large-scale demonstration activities.

During this decade, Europe's Rail shall deliver a high capacity integrated European railway network by eliminating barriers to interoperability and providing solutions for full integration, covering traffic management, vehicles, infrastructure and services, aiming to achieve faster uptake and deployment of projects and innovations. That should exploit the huge potential for digitalisation and automation to reduce rail's costs, increase its capacity and enhance its flexibility and reliability, and should be based upon a solid reference functional system architecture shared by the sector, in coordination with the European Union Agency for Railways.

This Work Programme is construed on the SBA terms and conditions for the partnerships:

- Recital 15, which requires the joint undertakings **to deliver European added value compared to calls under the main Horizon Europe work programme.**
- Recital 16, which confirms Horizon Europe principles of *openness and transparency, strong leverage effect and long term commitments*. In particular, *partnerships should be open to any entity that is willing and able to work towards the common goal, should promote broad and active participation of stakeholders in their activities, membership and governance, and should ensure that the results would be for the benefit of all Europeans, in particular through a broad dissemination of results and pre-deployment activities across the Union.*
- Recital 19, where it is clarified that *Horizon Europe Regulation requires that the **financial or in-kind contributions from members other than the Union should be at least equal to 50 % and may reach up to 75 % of the aggregated joint undertaking budgetary commitments.** Also, that the Union should be in a position to reduce its contribution if members other than the Union fail to fulfil their commitments.*
- Recital 21, that establishes that *in line with the ambitions set out in the Horizon Europe Regulation, one of the preconditions of setting up institutionalised European partnerships is ensuring partners' contributions throughout the lifetime of the joint undertakings... Joint undertakings should be able to identify measures to facilitate those contributions through their work programmes, **in particular by reducing funding rates.** In duly justified cases, it should be possible to **introduce additional conditions that require the participation of a member of the joint undertaking** or their constituent or affiliated entities, targeting activities where the industrial partners of the joint undertaking can play a key role such as large-scale demonstrations and flagship projects closer to the market, and **contribute more via lower funding rates.***

On these basis, this Work Programme sets the activities of the JU for its first years, and in particular (See Section 2.3.8):

- a first Call for Proposals – lump sum grant model – under Industrial Research for innovation activities to be performed in the following 4 years, largely building upon the R&I results of S2R

and other programmes to bring them at and above TRL 7, on average, in some cases to reach TRL 9. In line with the aforementioned SBA principles, **this call is set at 60% funding rate for each action; each Consortia may decide internally different funding rates in line with the provisions of Article 34 of Horizon Europe, nevertheless complying with the overall funding rate of 60%. This means for JU Members which would apply and possibly become beneficiaries a net funding rate of 45% (41% considering their contribution to the running costs of the JU).** The flat rate approach is set, also, to preserve the right to equal treatment between the different JU members which intend to apply to calls and whose nature spans between private and public, profit and non-profit. Although the SBA would allow introducing additional conditions that require the participation of members, it is considered that, at this stage, such approach would be colliding with the principle of openness and inclusiveness and limit the opportunity for a large involvement of the European rail sector – at all levels of the rail research and innovation value chain – to participate.

- **a second Call for Proposals – expected in Q3 2022 – in relation to Exploratory Research and Others, whose conditions will be set in line with Horizon Europe standard funding rates,** inter alia. The specific scope and nature of this second Call will be proposed to the Governing Board in an amendment to the present Work Programme at the GB meeting of 24 June, taking into consideration the input received from the SRG, the scientific advice and any other relevant stakeholders’ group.

In the context of the S2R Programme, around EUR 37 million⁷ were awarded to Research Organizations/Higher or Secondary Education (H2020 classification) covering some Exploratory Research and largely Industrial Research; in the context of EU-Rail, in addition to the openness and inclusiveness established for Industrial Research, EUR 63.5 Million are available specifically for “Exploratory Research and Other” in addition to EUR 50 million for the System Pillar which will require to integrate expertise from the same organizations (see also Section 9 of the MAWP⁸ and Section 2.3.1 of this Work Programme).

- these initial two calls are expected to be followed yearly, during the timeframe of this Work Programme, by Calls for Proposals for Exploratory Research and Others at the same standard HE conditions, unless concerns in relation to openness, inclusiveness and level of contributions would require reassessing them (see also Section 9 of the MAWP⁹ and Section 2.3.1 of this Work Programme).

Section 2.3.5 of the Work Programme presents the “waves” of calls planned during the EU-Rail life; subject to

- the outcome of the first Industrial Research call (openness, inclusiveness, contributions, etc.),
- the first project results, and
- an in-depth internal Programme Review in the second half of 2025,

the Governing Board will be provided with any relevant corrective measure to address possible concerns in relation to openness, inclusiveness and level of contributions, in accordance with the SBA.

⁷ Excluding UK entities

⁸ MAWP available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

⁹ MAWP available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

In addition to the aforementioned Calls for Proposals, this Work Programme highlight some major opportunities for participation (see Section 2.3.9 of this Work Programme):

- a call for tenders (5 years) to implement the activities of the System Pillar construed around three main areas – System Pillar management, System Pillar delivery, System Pillar baseline maintenance – that will provide the opportunity for experts/professors/engineers from the research and innovation community, infrastructure managers, rail operators, suppliers and other sector to contribute setting up the next generation of rail via the definition of concept of operations and system architecture.
- a series of call for tenders to complement the Programme activities availing the JU with the necessary expertise to deliver specific independent content related results.

The launch of the Research and Innovation activities of this Work Programme shapes the mission-oriented nature of the JU, building on openness and inclusiveness, answering the call of the Member States and Parliament to deliver impact and added value to European citizens. Synergies with other Union – as well as national and regional – programmes and partnerships shall provide opportunities to complement the series of actions expected from the rail sector, including interacting with ERRAC on complementary activities. Stakeholder relations and dissemination of results ensure the visibility of the progress achieved. Sound financial and risk management, compliance will underpin the implementation of the Programme along its lifecycle.

2.2 Executive Summary 2022

The European Green Deal¹⁰ and the related Roadmap¹¹, published in December 2019, form an integral part of the European Commission’s strategy to implement the United Nation’s 2030 Agenda and associated Sustainable Development Goals.

The European Green Deal sets out a clear vision of how to achieve climate neutrality in Europe by 2050 and presents the EU’s new growth strategy. To achieve climate neutrality, a 90% reduction in transport greenhouse gas emissions is needed by 2050. The transformation of the railway system will be pivotal to achieve the environmental and economic objectives by offering both decarbonised and time/cost-competitive transport solutions for passengers as well as for freight.

In December 2020, the “Sustainable and Smart Mobility Strategy – putting European transport on track for the future”¹² was adopted by the Commission. It fosters, besides other concepts, the idea of using the potential of digital technologies to revolutionise the way we move, making our mobility smarter, more efficient, and also greener. The Strategy identifies concrete milestones, and, in order to meet them, particular goals to be achieved by means of rail research and innovation are set as well, such as:

- a shift of a substantial part of the 75% of inland freight carried by road towards transport by rail and inland waterways,
- scheduled collective travel under 500 km should be carbon-neutral by 2030 within the EU.
- traffic on high-speed rail will double by 2030 and triple by 2050.
- rail freight traffic will increase by 50% by 2030 and double by 2050.

¹⁰ https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf

¹¹ https://ec.europa.eu/info/sites/info/files/european-green-deal-communication-annex-roadmap_en.pdf

¹² https://eur-lex.europa.eu/resource.html?uri=cellar:5e601657-3b06-11eb-b27b-01aa75ed71a1.0001.02/DOC_1&format=PDF

- a fully operational, multimodal Trans-European Transport Network (TEN-T) for sustainable and smart transport with high speed connectivity by 2050.
- improving the competitiveness of rail and supporting the European technological leadership in rail.

Further to the topic of “Digital Decade”, the Commission indicated in its Communication of March 2021¹³ how digital transformation can improve the ecosystems related to mobility and transport. Digitalisation can improve environmental and cost performance and simultaneously increase safety levels contributing to a higher quality of life. It will be achieved through more advanced levels of automation, faster and more reliable connectivity, and IT enabled profound transformation of the management of mobility services. The public could also benefit from fast internet connectivity for passengers on most stations and lines, user oriented telematics and facilitated multi-modality.

In this context, EU-Rail and its Programme will strive for speeding up the development and deployment of innovative technologies in railway transport in order to contribute to achievement of the above mentioned milestones. This will require a significant transformation of the railway sector, addressing long overdue changes in legacy operational processes, systems and governance models, as well as integrating with other transport and mobility solutions for passenger services and cargo logistics.

The strategic framework for EU-Rail’s endeavours is provided in its Master Plan identifying the ambitions and the objectives of this new partnership and defining a systemic, long-term and result-oriented delivery strategy for research & innovation in the railway sector.

More specifically, the JU’s 2022 priorities in this respect will be on:

1. launch the research and innovation activities identified in the MAWP in the horizon up to 2026, considering the resources available implementing the multi-annuality by instalment, with the publication, evaluation, award and grant preparation of two calls, one expected during Q1 and the other Q3 2022,
2. launch and ramp up the System Pillar activities and achieve the first element of the concept of operations and system architecture, to set the basis for the future work of the System Pillar,
3. set up and activate the new governance structure of the JU, in particular with the System Pillar Steering Group and Deployment Group,
4. review and define the new structure, processes and procedures that would ensure the sound management of the EU-Rail activities, with particular regard to the interaction of the two Pillars to maintain the nature of one integrated R&I Programme
5. explore new areas of R&I that will contribute to foster the system transformation of railway and non traditional and emerging technologies for land guided systems;

in addition, the projects of the S2R Programme will enter their final phases, focusing on:

6. delivering the R&I for the ERTMS game changers (telecoms, localization, moving blocks, automation), also in view of their integration in the TSI 2022 package, with the objective to ensure the evolution of the system towards Baseline 3 and its market uptake;
7. implement and obtain final results on the technologies demonstrated through R&I in relevant environment or even system prototypes demonstration in operational environment. In this respect, possible integration of TD (Integrated Technology Demonstrators) will also be fostered in the different IPs, with a view of showing them at InnoTrans 2022.

These priorities will build upon the monitoring and review of the ongoing R&I activities to ensure the delivery of the results expected for the demonstrators and to pave the way for the next generation of the Rail Research and Innovation Programme.

¹³ <https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A52021DC0118>

In the upcoming period, EU-Rail will continue to maintain, and even widen, its relations with the different stakeholders and external parties, such as the European and national decisionmakers, the JU members, other participants to the JU activities, European and national funding bodies, and also forwarders, carriers as well as the transport and passenger traffic associations.

The year 2022 will seek the continuation of the close collaboration established between EU-Rail and:

- the European Railway Research Advisory Council (ERRAC),
- the European Union Agency for Railways (ERA),
- other programmes and partnerships, such as the FCH JU, SESAR 3 JU, CLEAN SKY 2 JU, etc. with the objective to establish synergies that will result in coordinated and consistent activities, up to joint projects,
- different associations representing the key stakeholders of the rail sector and beyond,
- third countries programmes, in line with the policy priorities of the Commission and considering the key objective of the competitiveness of the European rail industry.

Since 2017, the JU has started working on Memoranda of Understanding (MoU) or cooperation agreements with European Regions: two were signed since then, with the Czech Republic and the region of the Basque Country. In addition, MoUs with different organizations and bodies were signed, such as CUTRIC, CEN/CENELC, ETSI and UIC. The JU will pursue its activities in this respect and exchanges are established with the Groningen Region (NL), Lower Saxony (DE), Alsace (FR), as well as with the rail research centres of Australia and Korea.

Stakeholder engagement will also continue to be developed within the context of the EU's external Transport Policy.

EU-Rail will continue participating in specific activities, workshops and events in order to advertise, communicate and disseminate the successful achievements of its Partnership. The JU intends to showcase its key achievements at events throughout 2022. Envisaged events include ITF (May 2022), the World Congress on Railway Research 2022 (6 – 10 June), InnoTrans 2022 (20 – 23 September) and the Transport Research Arena (TRA) 2022 (14-17 November). The preparations for 2023 EU-Rail Innovation Days are foreseen in Q4 2022.

A launch event of the EU-Rail partnership will take place in Paris, as part of the Rail Summit organized by SNCF under the events of the French Presidency of the Council.

In 2022, EU-Rail will build on the visibility gained during the European Year of Rail in 2021 to continue conveying the message to European citizens that rail can answer their concerns about unsustainable and unreliable mobility options. The JU's key messages and events will continue to reinforce the objectives of the European Green Deal and the Sustainable and Smart Mobility Strategy, by disseminating R&I results and showing the future evolution of rail in terms of services for passengers and freight clients. In addition, the European Year of Youth declared for 2022 will allow to continue to promote rail creating opportunities for communication with the young generations.

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

The communications strategy of Europe's Rail will aim to:

- showcase the innovative technological and operational solutions that result from the research and innovation activities, and in particular those ready to enter industrialisation and deployment, in particular demonstrating concrete impact;
- raising awareness on the research and innovation activities outreaching to the stakeholders at European level as well as engaging at global events/conferences to promote Europe's Rail results;
- enhance the partnership nature of the JU through communications and dissemination activities that will create opportunities for inclusiveness.

At the corporate level, EU-Rail will strive for appropriate workload distribution, as well as for costing and staffing levels needed to ensure successful delivery of the Programme. The foreseen gradual acquisitions of additional staff members, subject to the approval of the new Staff Establishment Plan, should contribute to this goal and to ensuring continuity of service delivery. In addition to supporting continuous learning and qualification raising of the staff, activities improving the well-being and team cohesion will be conducted throughout 2022.

2022 will also be demanding due to the phasing in of the next generation of the railway R&I Programme under the new partnership. In the last five years, the joint undertaking has demonstrated the progress achieved through the commitment of its members and stakeholders. The system transformation, to which the JU was expected to substantially contribute, does not end with S2R, as it will still require 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 Joint Undertaking has proved to be capable of delivering such major transformation, involving legislator, regulator, standardisation bodies and stakeholders.

2.3 Operational activities of EU-Rail in 2022

2.3.1 Objectives, indicators and risks

As mentioned in Section 1.4, the R&I activities of the EU-Rail Programme are structured around two Pillars, the System Pillar, which is structured in two main tasks and the Innovation Pillar that is organised in seven Flagship Areas (FA) and the Transversal Topic (TT). Their objectives and the main high-level risks associated to them are presented below.

The results of the JU shall be measured via a series of key performance indicators (KPIs) addressing, on the one hand, the technological and operational outcomes and, on the other hand, the impact that they are expected to realise once deployed. The KPIs shall cover the full lifecycle of R&I, from exploratory research to deployment coordination. The KPI model shall be based on input delivered by each of the JU projects and reported on a yearly basis, through the Annual Activity Report. Each project will be required to ensure that relevant quantitative and qualitative metrics are provided that contribute to the JU's overall KPIs. The model shall be finalized by the end of 2022, before the start of new projects under the Horizon Europe Programme. The current version of the KPIs at the level of the Flagship Areas and the Transversal Topic is provided in Annex III in Section 4.3 of this WP.

The System Pillar contributes defining the concept of Operations for Rail, through a System of Systems service-oriented approach, providing the overall framework for delivery of R&I, taking into account interfaces within different rail segments and other modes. These activities should ensure a common approach and efficient use of resources; EU-Rail is the platform for and provide the coordination and resources to enable sector convergence on common solutions at European level. EU-Rail shall therefore in particular coordinate and consolidate all relevant sector initiatives, noting the importance of unified requirements from the Railways. This is complementing and underpinning the focus on research and innovation towards impact-oriented solutions. Indeed, the work to define and then

maintain the operational concept and functional system architecture will be the framework within which the R&I work progresses with logical interactions.

The R&I activities to deliver the Concept of Operations, addressing the specific segments' interfaces, are structured within the Innovation Pillar and established around the full lifecycle of research and innovation, from exploratory research, via applied research to large scale demonstrations.

EU-Rail focus is on key priorities but addressing the subsystems of the various rail market segments and, where relevant and cost-effective, standardisation or commonly agreed harmonised specifications needed to deliver them. Automation will require converging on digital solutions, artificial intelligence, imaging, robotics, etc. but also addressing sub-components, e.g. mechanical, that otherwise would jeopardise the transformation to be delivered. In order to achieve such ambition, EU-Rail acts as "single coordinating body" to ensure the convergence of the sector towards the aforementioned new Concept of Operations and the related Reference Functional System architecture, both addressing different segments. This would allow setting the right conditions towards modular (standard interfaces), scalable, plug & play, etc. solutions in view of large-scale market introduction and their evolution.

R&I Large Scale Operational Demos will be one of the major game changers in the impact to be achieved by EU-Rail. It is not about coordinating the funding, it is about Integrated R&I Large Scale Demonstration activities, i.e. moving from small-scale demonstrators[prototypes] in one specific network or lab, to European wide live, operational network-scale demonstration of solutions in a different environment, reaching TRL 8/9 level, and to show the benefits from the European deployment of new solutions. This will also be a key component for the inclusiveness of these areas of Europe, and consequently, Member States, under-represented in the current rail research and innovation activities. As they will be capable to contribute to the definition of specifications and demonstrate the benefits of the proposed partnership, or ongoing Programmes, solutions in their operational network and services offered to their customers.

This activity will also support the necessary steps for the regulatory changes or standards' changes needed to bring solutions to the market, closing the virtuous circle started in the definition of concepts within the System Pillar, before industrialisation and deployment.

The "Deployment Group" will tackle the transition from R&I to coordinated and consistent deployment at European level, to avoid creating new barriers to a one single European network.

The table below present a summary of the main activities per year, for the years 2022 to 2024

Year 2022	Type of call	Value of the actions	Maximum EU-Rail co-funding	Non-funded activities	Target contributions from Members in case of award	Indicative publication date
Multi-annual Call for Proposals(*)	Open	390.0	234.0	156.0	302.0	Q1
	2022 values	226.2	135.7	90.5	175.1	

Year 2022	Type of call	Value of the actions	Maximum EU-Rail co-funding	Non-funded activities	Target contributions from Members in case of award	Indicative publication date
Call for Proposals– Exploratory Research	Open	14.5	12.5	2.0	4.3	Q3
Call for Tenders	Open	15.5	13.7	1.8	0.0	Q1–Q4 & implementation of new and ongoing contracts/framework work contracts
Operational Experts	Open, including through REA	0.4	0.4	0.0	0.0	Q1–Q4
Total		420.4	260.6	159.8	306.3	

Year 2023	Type of call	Value of the actions	Maximum EU-Rail co-funding	Non-funded activities	Target contributions from Members in case of award	Indicative publication date
Multi-annual Call for Proposals (instalment)	Open	0.0	0.0	0.0	0.0	
	<i>2023 values</i>	<i>122.5</i>	<i>73.5</i>	<i>49.0</i>	<i>94.9</i>	
Call for Proposals– Exploratory Research	Open	6.0	6.0	0.0	0.0	Q4

Year 2023	Type of call	Value of the actions	Maximum EU-Rail co-funding	Non-funded activities	Target contributions from Members in case of award	Indicative publication date
Call for Tenders	Open	13.5	11.7	1.8	0.0	Q1–Q4 & implementation of new and ongoing contracts/framework work contracts
Operational Experts	Open, including through REA	0.4	0.4	0.0	0.0	Q1–Q4
Total		19.9	18.1	1.8	0.0	

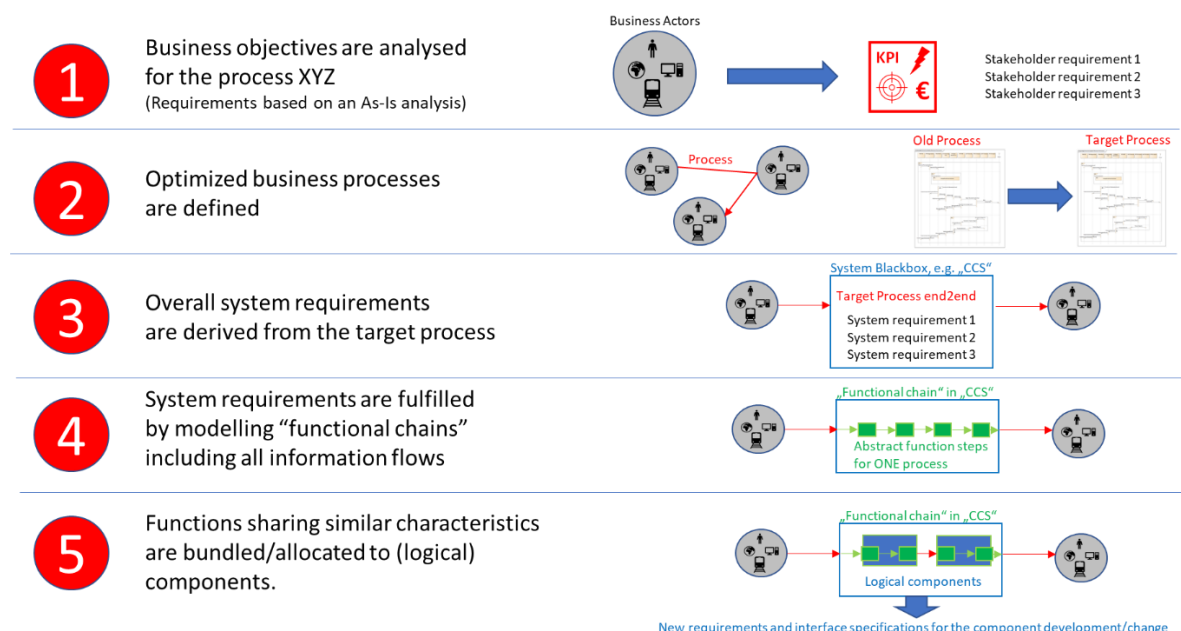
Year 2024	Type of call	Value of the actions	Maximum EU-Rail co-funding	Non-funded activities	Target contributions from Members in case of award	Indicative publication date
Multi-annual Call for Proposals (instalment)	Open <i>2024 values</i>	0.0 <i>41.3</i>	0.0 <i>24.8</i>	0.0 <i>16.5</i>	0.0 <i>32.0</i>	
Call for Proposals– Exploratory Research	Open	6.0	6.0	0.0	0.0	Q4
Call for Tenders	Open	11.7	11.7	0.0	0.0	Q1–Q4 & implementation of new and ongoing contracts/framework work contracts

Year 2024	Type of call	Value of the actions	Maximum EU-Rail co-funding	Non-funded activities	Target contributions from Members in case of award	Indicative publication date
Operational Experts	Open, including through REA	0.4	0.4	0.0	0.0	Q1–Q4
Total		18.1	18.1	0.0	0.0	

(*) this call for proposals will be launched implementing multi-annuality by instalment, meaning that the amount committed by the JU will be confirmed yearly based on the annual budget of the JU. For more information about the annual instalments, please refer to the “Table of Financial programming per year until 2027” in the chapter 3 Budget 2022-2024 of the present document

2.3.2 The System Pillar

To achieve an architecture that offers the demanded functional improvements concerning production performance, reliability, quality, and cost as well as the needed architecture quality the System Pillar shall analyse the business processes in scope. For the operational processes the following deduction steps shall be considered:



This is an iterative process where the results in step 5 will have to be verified against the business objectives in step 1, to ensure their coherence and feedback.

The proposals on architecture outlined here are early drafts that the System Pillar will have to develop also in collaboration with the Innovation Pillar, constituting the shared and ambitious vision of the

sector on how to operate rail in the next decades. Thus the proposals shall be understood as draft preliminary versions. The purpose of their presentation here is not to define or propose the architecture of the SERA concept, but rather to develop sufficient understanding to develop the scope and tasks of the System Pillar.

The first step is to define the full perimeter of interest of the rail system, while being as independent as possible of specific technologies.

Using this point of view, the railway system can be indicatively broken down according to the following independent & complementary functional layers:

- **Manage customer services** which captures the business functions managed by the railway system that are visible from the end-users (either train passengers or freight customers);
- **Operate railway system** which covers authorisation, monitoring & control of the railways and operations of the railway network and its traffic, including the operational features and principles to operate the network and support operation of trains;
- **Control & command trains** which enables operating the railway system, including command control of the movements of trains authorised to travel on the network and all train control functions required to ensure safety or automation;
- **Manage energy** which deals with the basic functions dedicated to energy management, both off and on-board;
- **Manage communications & physical infrastructure** which contains the basic functions that are managed by the communication & physical infrastructure;
- **Manage railway crew, fleet & assets** which consolidates all the functions related to human or technical reliability, availability, maintainability, safety & security of the railway system.

These functional domains correspond with the sub-systems that are defined by the Interoperability Directive as one can see in Figure 63 that presents an indicative generic global high-level architecture for a railway system.

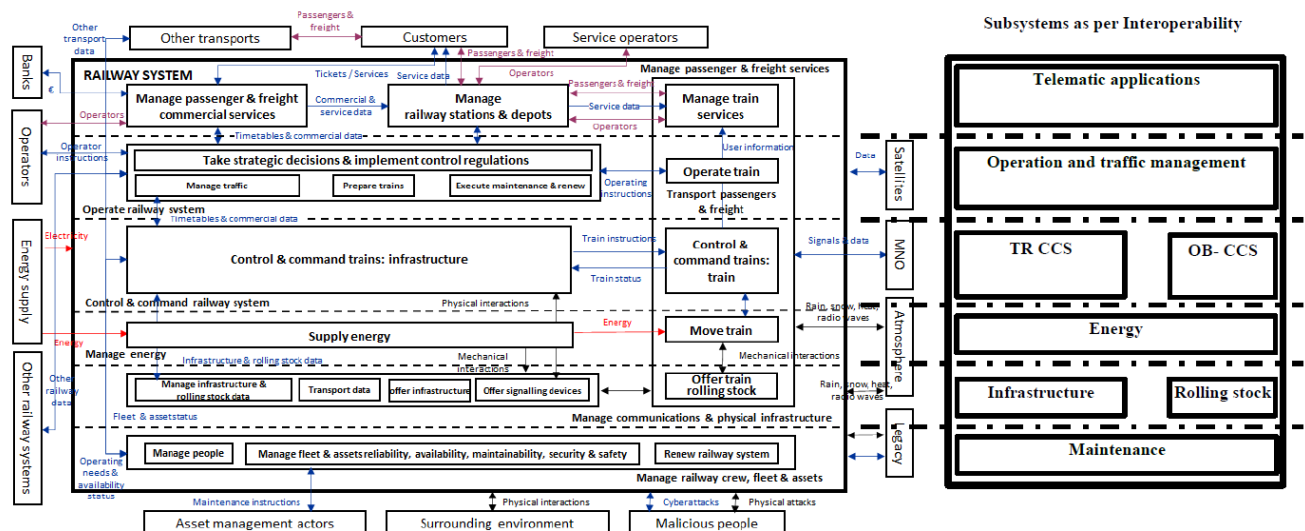


Figure - domains of the railway system and their alignment with sub systems as defined in the Interoperability Directive

Note that the railway system functions that are described in the above architecture are split here according to their on-board or off-board nature, if needed. On-board functions are the railway system functions provided by a train, seen here as sub-functions of the global “transport passengers & freight” function which models functionally the train, where off-board functions refer to all the other railway system functions which are not provided by a train, but by the various elements of a railway system

(trackside infrastructures, control & command information systems, operating centres, depots, railway stations, commercial departments, maintenance organizations).

Given that it is necessary to define the whole rail system in order to determine the areas of priority and focus, and in order to ensure consistency of approach, Task 1 of the System Pillar will define the high-level overall railway architecture and operational concept for the EU Rail System.

2.3.2.1 System Pillar Task 1: EU Rail System

The European railway system is an open, shared, dynamic structure composed of assets that are fixed in space and mobile, owned and managed by different actors. Geographic position, speed and operational conditions of mobile assets matter. Mobile assets have either local interaction with fixed assets, and/or through a wide-area communications network. Both types of assets can be connected to a control network for operations and maintenance.

The System Pillar Task 1 will be focussed on the European railway network to which Directive 2016/797 applies.

The vision of the European railway system is:

- Open access to SERA, i.e. no technical and operational boundaries for trains, standardisation (economies of scale), safety (including learning from information sharing) and resilience;
- Performant and competitive;
- Synchronised deployment, and
- Full alignment with the future system

The system architecture used by the System Pillar needs to be structurally and logically consistent.

The system architecture needs to reflect the structural reality that, currently, there is no single European railway system. However, the objective of technical and service integration into a seamless European rail system needs to be maintained and interfaces need to be defined accordingly.

Consistency with the definitions in the Interoperability Directive, in particular the various Subsystems and Interoperability Constituents, needs to be considered. However, these definitions may evolve if necessary, based on the results delivered by EU-RAIL.

The target architecture(s) will consider the optimal level of technical and safety harmonisation building on cutting edge technologies, making it possible to facilitate, improve and develop railway services within the Union, and with third countries, and to contribute to the completion of the SERA and the progressive achievement of the internal market. Interoperability must be achieved and maintained.

The scope of Task 1 should not be time-bound, and can consider several iterations of development i.e. it should be ambitious and flexible to take into account the impact of new technologies and processes with regards to rail (e.g. from the innovation pillar) which may require a substantial revision of, *inter alia*, safety concepts and the regulatory framework underpinning operations.

To achieve the overall evolution and target architectures defined in Task 1 will be a complex challenge. Best practice from other industries shows that successful integration of system architecture approaches, especially when moving from current engrained systems like in rail, is to take the opportunity when systems are in any case evolving to put in place the correct system architecture processes and principles.

Thus, the justification for Task 2 of the System Pillar in the area of Control Command and Signaling (CCS).

2.3.2.2 System Pillar Task 2: CCS+ & other work packages

The regulation and implementation of European rail control-command and signalling (CCS) is of central importance in the running of a safe, efficient, interoperable, robust cost-efficient and reliable rail service in Europe. CCS deals with all the on-board and trackside equipment required to ensure safety and to plan, command and control movements of trains authorised to travel on the network as well as the efficient integration of maintenance processes that occupy tracks¹⁴.

Historically it was simply the train driver's responsibility to follow signals, but with higher speeds (> 160 km/h), optical trackside signals were no longer sufficient and therefore supplemented by cab signalling. Over time automatic systems were developed to monitor drivers' operation (continuous speed monitoring and avoidance of signals passed at red). These systems have been developed to be different and they are still substantially different in each national railway network, and thus a major barrier to operate one European network.

A central focus at European level has been the implementation of ERTMS (European Railway Traffic Management System), a major industrial programme to harmonise the automatic train control and communication system and underpin interoperability throughout the rail system in Europe. Deployment of ERTMS provides the backbone for a digital, connected Single European Rail Area.

Significant steps have been taken to address core issues relating to the achievement of an interoperable rail system based on ERTMS. Despite a very slow start, there are now coherent and ambitious plans across the EU to deploy ERTMS in the coming years.

The current harmonisation at European level, through the CCS TSI, addresses the safety and interoperability requirements, the on-board functions and the interfaces between trackside and on-board related to train protection, signalling the permission to move the train and radio communication. Hence, not the full CCS system.

For trackside CCS beyond that specified in the CCS TSI, there is currently a network or deployment specific approach of trackside engineering, operational concept, signalling rules and their interfaces – for example route setting and protection, which are not harmonised in the TSI CCS and are implemented following national or company specific rules.

The current typical CCS on-board configuration includes multiple proprietary TCMS (train control management systems) and Class B driven interfaces between the main train on-board building blocks, which are currently not harmonised. This induces low on-board upgradeability and dependency on the initial suppliers when on-board upgrades are necessary and, consequently, increased cost and complexity.

As a result, even if ERTMS as it stands is implemented in full across the EU, national systems for significant parts of the CCS system would continue, along with national operational rules driving

¹⁴ CCS+ is not only about the movement of trains. A large part of the control processes deal with the efficient access of construction and maintenance processes that occupy the track. Cost reductions can be achieved for those processes by integrating their planning, granting and supervision processes into the automated CCS+ landscape. At the same time the duration of occupation times can be reduced.

customisation, and a continued overall fragmented CCS market of signalling configurations and rail business models.

Modern planning and control technologies can make use of the full potential of ERTMS to fine control a traffic flow in a much more performant, adaptive and robust way. The key is to simplify and empower the production automation architecture by eliminating hindering legacy technologies that were developed long before ERTMS. Additionally the connectivity shall be increased to integrate new or cross sector end-device technologies with higher cost-efficiency and performance.

This situation significantly increases CCS complexity and reduces the opportunity for more open and competitive markets across Europe. It also creates a system that is not conducive to harmonised evolution and innovation and induces errors and incompatibilities in implementation of the TSI regulated interfaces. Finally, it undermines the performance of the rail system in favour of clients opting for other mobility and transport solutions.

Hence the CCS+ task is to develop the operational concept(s) and functional system architecture for a genuine integrated European CCS system, supported by a model-based systems architecting & engineering approach, beyond the current specifications in the CCS TSI, with much greater standardisation and much less variation than at present. This integrated CCS system shall on the one hand deliver unrestricted movement of trains, on the other hand, it shall create a single market for rail components.

CCS – both on-board and trackside - shall be based on a standardised modular system architecture using standardised interfaces. In order to preserve investment made, the System pillar should not only create adequate interface but care about migration feasibility (i.e. clear and affordable transition steps) and find paths for moving beyond the current system with proprietary interfaces and allowing modularity of components.

The software and hardware installed on board or trackside should be operated and maintained following principles and standards as used in the IT or industrial automation domain: regular, scheduled updates with pre-tested configurations ensure errors and shortcomings are eliminated, maintaining all the products and system throughout EU in line with the interoperability specifications, with manageable upgrade mechanisms.

The need for the CCS+ task is because digitalisation technologies are ready for use in rail with huge potential to improve passenger and freight services. Digitalisation coupled with automation is the most effective way to increase performance and capacity with less new infrastructure investments. Without high quality architecture, adding such new technologies and maintaining compatibility will not be possible.

The purpose of the focus on CCS+ is therefore to take advantage that as networks and Member States migrate to CCS systems of ERTMS L2 or above – the opportunity is taken to do this in a harmonised manner following functional layered architecture principles: this will set a common baseline that will allow to evolve systems at the technological evolution pace. It will be a major change from “black boxes” to “software solutions” computing environments.

Operational interoperability is an equally important goal of the Single European Rail Area.

A properly designed radio-based ERTMS can significantly reduce the trackside cost, complexity, and network specificities of classic ERTMS Level 1 and class B lineside signalling and provides the opportunity to streamline the operational principles and technical specifications for ERTMS and wider CCS components and functions – improving interoperability and the overall performance of the system.

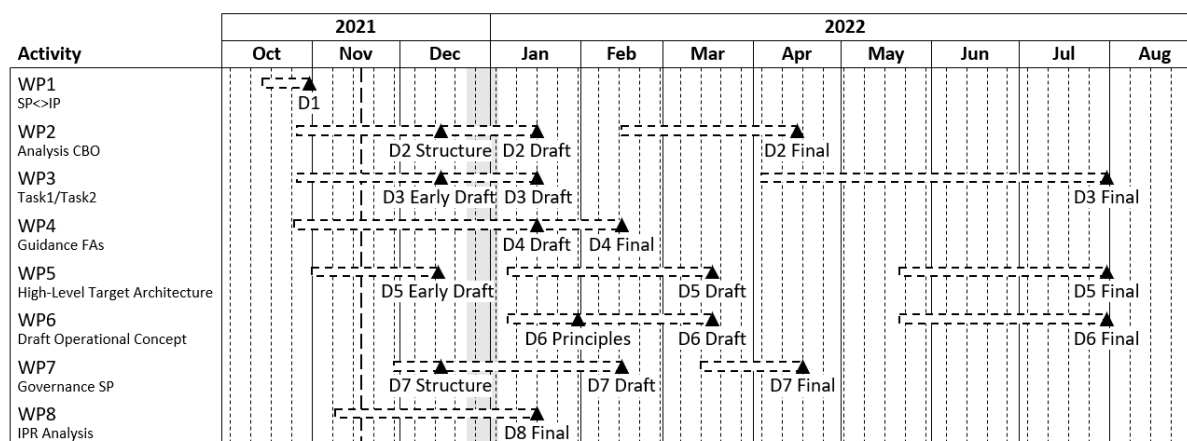
A further major opportunity is thus to create harmonized operational rules.

On this basis, a converging shared vision on future rail operations based on ERTMS-alone Level 2 and Level 3 networks will set up the baseline for the operational and technological solutions to ensure and continue evolutions of rail.

In addition, Task 1 and Task 2 will have to encompass concept(s) of operations definition and architecture elements for other areas of research and innovation, such as DAC in the context of Flagship Area 5 below.

2.3.2.3 Objectives and progress of the works

The chart below present the planning of the work and the expected deliverables for each work package identified in the ramp up phase of the System Pillar. In fact, EU-Rail made available resources already mid-2021 to enhance the work on concept(s) of operations and system architecture to pave the way for the establishment of the System Pillar with the entry into force of the SBA. These activities include a series of deliverables setting up different elements for the process and governance of the functioning of the System Pillar and the interaction with the Innovation Pillar, but also initial elements from the content point of view to contribute to the ramp up phase of the future Innovation Pillar Projects.



The results are planned by mid 2022, when the formal structure of the System Pillar will be set and duly funded via a tender procedure (see below), that is expected to be fully operational in Q3 2022 and align its activities during the grant preparation phase of the Innovation Pillar Projects.

The management of the activities of the System Pillar will require a strong governance and monitoring which is under development and integrated in the EU-Rail Governance and Process Handbook, under the responsibility of the Executive Director supported by the System and Innovation Programme Board.

2.3.3 The Innovation Pillar

The Innovation Pillar is structured in 7 Flagship Areas leading to large scale demonstration as defined in the SBA, complemented by Transversal Topics which ensure the engineering integration of the Programme.

2.3.3.1 Flagship Area 1 (FA1): Network management planning and control & Mobility Management in a multimodal environment

The main objective of the FA1 is to dramatically improve the flexibility, efficiency, resilience and capacity adaptation of the European rail network – supporting the development and operation of a Single European Rail Area. The objective is to develop the functional requirements, associated specifications, and operational and technological solutions to enable future European Traffic Management. This will include the requirements to make common train operations and ticketing possible. This will enable the design of future network management, planning, and control.

To achieve the overall objective, several streams of improvement have been identified:

- Operators need to be able to adapt quickly to possible deviations or disruptions and last minutes changes in demand.
- Increased flexibility paves the way for smarter and tailored door-to-door services and offers, where mobility solutions meet the expectations of passengers and logistics.
- Maintaining the reliability of rail traffic requires all subsystems that influence the traffic to be connected to the Traffic Management System, in order to collect information in real time.
- Enhanced integration of the rail networks should allow to extend capacity planning and operation at European level, enabling capacity optimization and automatic management of cross-border traffic by predicting and controlling routes of cross-border trains in European networks and corridors.

The operational outcomes to be achieved in FA1 will be:

- Improving strategic and tactical planning of the rail network
- Increasing the resilience of a connected 'real time' rail network
- Integrated rail traffic within door-to-door mobility

The main risk preventing or delaying the delivery of the objectives in this Flagship Area remains the lack of coordination and interactions between the various actors, the organizational framework and the deployment strategy not well defined or not implemented, and potentially the lack of European regulations to enforce it.

2.3.3.2 Flagship Area 2 (FA2): Digital & Automated up to Autonomous Train Operations

The targeted objective of FA2 is to take the major opportunity offered by digitalization and automation of rail operation and to develop the respective systems. This includes next generation Automatic Train Control (ATC), including Automated Train Operation (ATO) Grade of Automation (GoA) 4, building upon radio-based European Rail Traffic Management System (ERTMS) or above, representing the next evolution of the system, incorporating the latest technological advances, and with functionalities enabling full optimisation of performance in line with the Traffic Management improvements developed in FA1. FA2 will aim at delivering scalable automation in train operations with fully unattended train operations including setting a train in motion, driving and stopping the train, opening and closing the doors, remote train control and recovery operations in the event of disruptions.

The expected effects of FA2 are:

- Reduce the cost of capacity, which is a major indirect catalyst for capacity optimisation.
- Allow precise traffic flow management, supporting punctuality, reliability, and productivity improvements.
- Allow the control of much higher train densities with a significantly reduced Life Cycle Cost (LCC) of CCS components compared to today.
- Deliver scalable solutions fitting for high- and low-density lines, supporting the generation of large-scale component markets and standardisable industrial asset management processes as well as to speed up the deployment and ensure long term evolvability of the system.

Potential restraints by the public to travel with automated trains, or the question of acceptance of automated cargo trains loaded with hazardous substances, might represent one of the risks associated with introducing Digital Automated Train Operations (DATO) under FA2.

Another risk is related to the migration to DATO soft- and hardware, where a clear functional separation between subsystems must be achieved. A clear interface with Traffic Management System (TMS) is crucial for implementation as well. The migration risk is also linked to the difficulty of the long lead time of European Train Control System (ETCS) deployment, which shall be mitigated by reducing the cost and by agreeing on an effective EU deployment process, while research and innovation advances.

Furthermore, the risk of not having a ‘fit-for-all’ legal sector agreement that will allow for sharing and reallocating liabilities, risks, costs, and benefits across the stakeholder groups, might decelerate the implementation of digital and automated train operation technologies. The business risk might be an issue as well, since the benefits (e.g., capacity increase, mainly for governments) may not be reaped by the same players that will pay for the costs (Infrastructure Managers, Railway Undertakings, and industry), which might lead to postponements, or even avoidance of future investments. The role of the System Pillar to anticipate such risks and to deliver the necessary input to FA1 is important in this respect. Economical, legal, regulatory and organizational implications need to be assessed and jointly agreed upon in the rail sector, which goes beyond the technical scope of FA2.

2.3.3.3 Flagship Area 3 (FA3): Intelligent & Integrated asset management

This Flagship Area has the objective to provide new innovative technical requirements, methods, solutions and services – including technical requirements and standards for future developments – based on the latest leading-edge technologies to minimise asset life-cycle costs or extend life cycles while meeting the safety and improving the reliability, availability and capacity of the railway system, addressing both infrastructure and rolling stock.

The expected result will be a common European asset management framework composed by a green, digital and safe set of solutions for the rail sector, focusing on three interrelated areas:

- Cost-effective asset management addressing short, mid and long-term interventions widely supported by digital (diagnosis) technologies and data analytics.
- Advanced and high-tech automated execution of construction and interventions supported by robotics and wearables changing the way of working improving health conditions for workers involved and increasing quality and consistency of the results.
- Environmentally friendly production of resilient assets, supported by new design principles, solutions and fabrication techniques.

The risks for FA3 may include extensive cost associated with the market uptake of final solutions due to missing business cases. Siloed proposals for technologies, not considering overall value chain demonstration cases and the integrated approach, might represent another issue.

A different type of risk for this Flagship Area can result from unfit or underdeveloped reference system architecture framework and Conceptual Data Model (CDM), preventing from correct integration of innovations.

Another example of potential risk may lie in the certification processes for new assets, systems, or processes, as well as in reluctance of human factor to accept human-machine interfaces (e.g. augmented reality) in the design and utilisation of innovation.

2.3.3.4 Flagship Area 4 (FA4): A sustainable and green rail system

FA4 pursues the objective of providing new innovative products and services based on leading edge technologies to minimize the overall energy consumption and environmental impact of the railway system, to make this transportation mode healthier, more attractive and to provide resiliency against climate change at a reduced total cost of ownership.

This Flagship Area should provide the following solutions:

- Developments oriented towards a more integrated and standardised Rail Power Smart Grid, integrating greener energies, cutting peak of energy consumption and allowing for a better control and management.
- Developments oriented towards a better energy management at station level (stations as energy hubs) providing more intelligent and integrated control systems and allowing for a larger energy flexibility and resilience of the Electrical Smart Grid.
- Technologies for a more sustainable and extreme hazard resilience design of railway infrastructures and rolling stocks, oriented towards the whole life cycle of the assets and supported by Digital Twin developments.
- Sector tools or platforms for the efficient implementation of circular economy solutions in the railway sector (infrastructure, rolling stock and buildings) and for sharing and communicating of accurate environmental data towards stakeholders.
- Guidelines for the design of modular stations according to size and uses.

One of the main risks associated with FA4 relates to the fact that the relevant technologies for achieving sustainable and green rail system (e.g. hydrogen solutions, batteries, sustainable construction technologies) are primarily developed by other industries and under partnerships other than EU-Rail. This might cause difficulties in transferring these innovations directly to railways for reasons such as the cost of technologies, incompatibilities of standards, or other technical constraints.

Some risks mentioned under FA3 are relevant for FA4 as well. This applies to the risk of having extensive cost associated with the market uptake of final solutions due to missing business cases. Siloed proposals for technologies, not considering overall value chain demonstration cases and the integrated approach, might represent another issue.

Finally, long and costly homologation procedures for new assets, systems or technologies represents another risk to achieving the objectives under this Flagship Area.

2.3.3.5 Flagship Area 5 (FA5): Sustainable Competitive Digital Green Rail Freight Services

The objective of FA5 is to make rail freight more attractive through increased capacity, e.g. with Digital Automatic Coupler (DAC), which is enabling more functionalities in freight to increase network capacity in a smart way for all types of rail freight transport, as well as significantly improved cross-border operations and multimodal customer services. Increased capacity is the key factor to enable a shift of transport volumes to rail, reducing substantially the related greenhouse gases emissions.

FA5 tackles the challenges by having two clusters which are interlinked but still distinct. The first one is “full digital rail freight operations”. It is focused on increasing substantially the productivity, quality and capacity of rail freight by full digitalization and automation of operational functions and processes including innovative freight assets. The second cluster, “seamless rail freight”, is focusing on important aspects to increase the efficiency of the immaterial (information/data) layer of transport and to gain time and save costs by ensuring a seamless environment (between different actors/countries/modes for planning/execution/management) in the long term, but also via short-/medium-term achievements and quick wins.

One of the major risks to the objectives of FA5 is that unclear and changing business cases as well as varying use-cases could lead to unwanted re-iterations in the development of innovations. Such

iterations may result in failure to achieve authorisation/certification and could lead to higher investment costs.

In addition, the developments can be hindered by the lack of operational and technical information, or by the unavailability of data from legacy systems being the starting point for European and interoperable solutions. Another obstacle may take form of a delay in ERA's authorisation process or in the preparation of functional requirement specifications in order to meet TRL targets regarding technical enablers.

The number of different systems to be connected and the complexity of the systems can pose a risk to standardising and harmonising of processes, technologies and cross-border systems, which might delay achieving of the objective of European interoperability of systems.

Finally, the migration from a brownfield environment and underestimation of the complexity of adaptation may be a risk, especially if combined with missing operational rules and technical regulations/standards.

2.3.3.6 Flagship Area 6 (FA6): Regional rail services / Innovative rail services to revitalise capillary lines

The overall objective of FA6 is to ensure long term viability of regional railways by decreasing the total cost of ownership (TCO), in other words, cost per kilometre both in terms of operational expenditure and capital expenditure, while offering a high quality of service and operational safety. In addition, the aspired results aims to increase customer satisfaction and to become an attractive and preferred choice of transport mode.

These goals are expected to be achieved through a concept tailored to regional railways that includes digitalization, automation and utilization of mainstream and emerging technologies for signalling and trackside components, rolling stock and customer information. Cost drivers including infrastructure and energy components, e.g. trackside train detection (axle counters, etc.) and level crossing control systems, should be replaced by less costly wireless and energy self-sufficient components. The foreseen solutions include alignment with System Pillar CCS Reference Architecture, cost efficient infrastructure and energy components, a light, flexible and modular vehicle concept as well as safety and asset management. In addition, a passenger information system should be introduced, allowing to benefit from the solutions available for mainline services while integrating data from regional railways with other modes of transportation and local services, offering added value for customers.

Nevertheless, to enable suppliers to develop technologies at competitive costs and allow an effective implementation and usage by the operators, several risks have to be taken into account, such as the lack of standardization and harmonization, insufficient alignment with TSI-revision cycles, or difficulties with adjusting technologies to specific needs of regional rail, hindering the expected demonstrations and pilots.

In addition, the migration from a brownfield environment and underestimation of the complexity of adaptation may be a risk, especially if combined with missing common operational rules and technical regulations/standards.

2.3.3.7 Flagship Area 7 (FA7): Innovation on new approaches for guided transport modes

The objective of FA7 is to explore non-traditional and emerging flexible and/or high-speed guided transport systems, as well as to create opportunities for innovators to bring forward ideas for shaping those future systems via a scientific approach into an existing rail system. This shall provide socio-economically efficient and long-term sustainable transport for citizens and businesses throughout

Europe. The main aspects for such systems are the reduction of energy consumption, noise and pollutant emissions and land consumption, the use of sustainable raw materials and energy sources and the sustainable use of existing infrastructures.

The vision under FA7 is to develop the next generation of railway transport systems as well as guided transport systems based on a fully automated multi-modal mobility system for passengers and goods which is sustainable, interconnected, digital, on-demand, standardised, scalable and suitable for all transport modes. While FA7 is generally open to all innovation on new approaches for guided transport modes, the focus will be on solutions which allow higher flexibility through multi-modality such as a transition to intermodal-connected moving infrastructure by centrally coordinated, innovative purpose-built vehicles and on ultra-high speed energy efficient and environmentally friendly rail systems. The innovation in this Flagship Area are expected to operate on an Open Platform, based on common standards and standardised interfaces, connecting all the transport modes, and be able to provide disruptive Operation and Business Models.

New approaches foreseen under FA7, like moving infrastructures, Pods, magnetic levitation, air levitation, and vacuum tube technique bring a lot of advantages and can be an important and possibly unavoidable component of the mobility of the future. However, several risks are associated with their deployment.

Firstly, a technological maturity is more difficult to be reached for such innovative systems compared to the evolution of existing systems. One of the particular challenges will be the conversion of the existing infrastructure of today's modes and railway mobility to above mentioned future solutions in a more sustainable and non-burdening way for the national economies. .

Secondly, a lot of gaps exist related to introduction and consolidation of legislation, as well as standardisation, for FA7 innovative technologies and solutions. A delicate balance needs to be found between having the technologies mature enough to define standards and regulations and setting up a regulatory framework as soon as possible to ensure that the developments fit the required legislation in matter of safety and to obtain the maximum compatibility, interoperability and intermodality.

Finally, risks linked to the sustainable construction of intermodal transportation and/or robust domestic or cross-border transportation lines need to be considered. These include, for example, handling with many different legislative/administrative processes at national and European level, or coping with the emerging climate changes when introducing these new transportation modes.

2.3.3.8 Transversal Topic: Digital Enablers

On the path of becoming fully digital and connected, the rail system will be characterized by a complex landscape comprising multiple heterogeneous enterprise-level mission-critical systems interacting with a very large number of networked stationary and mobile devices and sensors, generating requirements for new mechanisms to be embedded in the digital infrastructure.

Digitalisation is of major importance for all the Flagship Areas, hence it is organised as the Transversal Topic (TT) to have all elements of the system playing together in a coherent and interoperable way. The digital enablers from this work area – mainly the digital twins¹⁵, innovative processes enabled by interoperable data sharing as including common data model (CDM) will serve various demonstrations in the FAs.

¹⁵ A digital twin is a virtual representation which is able to imitate the behaviour of a physical system during the span of its lifecycle.

The objective of the transversal topic on digital enablers will support the operational processes and activities of the FAs by three aspects: firstly, the Digital Twins support by composition of reusable, blackbox, compiled, digital interoperable model units of components, subsystems, executing in a federated simulation runtime environment the DT to provide suitable analysis tools (e.g. root-cause analysis). Secondly, the TT will develop and provide a Digital Twins Design toolbox (design-time) to model development tools for design as well as for validation, verification and test; to model registry and discovery services and to model Interoperability validation tools. Thirdly, the TT will provide a Federated dataspace to feed digital twins in order to ensure a common Ontology, Identity and Trust management, Federation Services, Data Assets registry and discovery services, Data Distribution Services, Data stream management, cyber security etc.

There is a number of risks to the objective of enabling the fitting of individual digital twins in a joined environment, such as the potential lack of consensus, alignment, access to data or interoperability of systems. Thus, the risk exists that consolidation with other FAs will not be reached in time or in all needed areas to a sufficient extent.

Additionally, a lack of an agreed framework on rights and obligations as well as governance associated with use of a digital twin and federated data could hinder a proper usage of the developed digital environment.

Another risk associated with digital twin development is finding right complexity as well as granularity level. On one hand, creating a simple digital twin will mainly result in a digital model that cannot accurately represent the real system. On the other hand, creating a too complex digital twin will require substantial amount of work by orders of magnitude and can result in making it difficult to understand, maintain and debug.

Finally, transversality as such is a risk. Requirements and functionalities need to be collected from the FAs as well as the architecture developed in LinX4Rail (2019), and further development in the System Pillar needs to be considered. In addition requirements from different stakeholders and FAs need to be accommodated and integrated. Besides the content related challenges, this represents an issue for project management and governance.

2.3.3.9 Innovation Pillar specific objectives for 2022

During 2022, the main objective is to ensure that all the R&I activities identified in the Innovation Pillar are up and running, with the signature of grants related to HE actions in November 2022. This requires to achieve an ambitious timetable whose results will depend on a series of critical steps, from the launch of the multi-annual call in Q1 2022, to the professional independent assessment of the proposals at the end of Q3 2022 and focused grant preparation phase during Q3 and Q4 leading to the signature of the grants.

This first call will cover the first R&I activities till end of 2026, including a series of demonstrator as defined in the Call 2022 topics listed in Annexe VI of this document., The JU based on the reporting to be provided by the actions on a yearly basis will monitor the performance of the projects and decide on their continuation on the basis of agreed performance indicators.

2.3.4 Exploratory Research and Other

The activities relate to the System and Innovation Pillars shall be complemented by blue sky research, complementary research and other activities to ensure the successful implementation of the Programme. This will require external professional and independent expertise, support and know-how.

In this respect, a second Call 2022 is planned in Q3 2022 and its content will be defined on the input and advice of the Scientific Committee – or its successor as established by the Governing Board -, the States Representatives Group and possible specific needs identified by the ongoing actions or ERA.

The JU will also launch specific tenders to acquire solutions to enable the Transversal Topic, ensure effective Programme Management with sector expertise but also involve associations of stakeholders not represented in the JU Governance.

The definition of the second Call and the other activities may require the Executive Director to submit an amended Work Programme to the Governing Board for adoption at the end of Q2 or early Q3.

Another transversal topic for the transformation of rail (freight) towards an automated and digitised mode of transport is the continued management in 2023 and beyond of the so called European DAC Delivery Programme (EDDP), established and enabled by Shift2Rail in September 2020. For a successful and effective implementation of the Digital Automatic Coupler for European rail freight (DAC), it is of crucial importance to continue within Europe's Rail JU the already implemented and active open, close and efficient cooperation between railway undertakings, infrastructure managers and wagon keepers, as well as the rail supply industry, entities in charge of maintenance, concerned sector organisations, rail research centres and national and European political institutions, as started in 2020.

2.3.5 S2R R&I Programme

All available budgetary appropriations of the former S2R JU were committed by the end of 2021, before the entry into force of the SBA. The EU-Rail JU will continue collecting the cash contributions to be provided by the Members of the former S2R in accordance with the surviving provisions of the relevant regulation.

During 2022, the work of the former S2R Programme will continue to perform with the objective to achieve the demonstrators foreseen to be presented at InnoTrans 2022 and start the phasing out of the projects entering the final stages. These results will be essential inputs and constitute the baseline of the future EU-Rail Programme's Projects. Annexe IV, Table II provides the list of demonstrators and associated TRL levels expected in 2022.

EU-Rail will supervise the implementation of the S2R Projects to ensure their sound management, in particular to assess their progress to achieve the defined targets and the transition of results to the successor programme, when needed building upon the provisions of Article 31.5 of the grant agreement.

The Programme structure organized by Innovation Programmes and Cross-Cutting Activities is maintained to ensure that risks and opportunities are dealt by properly, while the former ED Programme Board is incorporated in the System and Innovation Programme Board, to be established by the end of Q1 2022.

The estimated amount of activities to be performed in 2022 is EUR 121.6 million in co-funding for the ongoing projects and tenders.

2.3.6 Other risks

The different activities of the EU-Rail Programme presented risks and opportunities that will require to be reassessed once the projects/taks/etc. are in place and effective.

In addition, the table below presents other relevant risks related to the management of projects, as well to the corporate management of the JU (such risks could also have indirect impact on operational activities), together with the corresponding risk-mitigation actions. These risks were identified as a result of a risk assessment exercise which was performed in the months of September and October 2021 and revised in the preparation of the present Work Programme. Within this exercise, the specificities resulting from the transition from S2R JU to EU-Rail were also taken into account, as well as other topical internal and external factors and developments having influence on JU's business.

The table shows specifically those risks which require, due to their criticality, continuous attention and treatment of the Executive Director and, where relevant, of the Governing Board.

Risk identified	Action plan
<p>Intrinsic to the JU Staff establishment plan, efficiency of operations is impacted by extensive workload, high staff turnover, together with difficulties for the JU to attract new people which may result in positions being filled in with delays, shortage of resources especially (during peak moments), and as a consequence, leading to difficulties in getting the work done and achieving the JU's objectives (continuity); this may include a negative impact on employees' motivation.</p>	<ul style="list-style-type: none"> - Subject to approval of the EU-Rail Staff establishment plan, 6 additional staff members should be introduced, with envisaged positive effects on workload allocation and back-ups in the following period. - A career plan for staff has been prepared. - Enhancing the planning of activities will allow for better personnel risk management. Recruitment of short term resources (interim or trainees) has been extended. - It is planned to introduce a new multi-annual learning and development policy. - The JU will built on the results of the projects started in 2021 which covered topics such as strategic support, workload, cultural aspects, and coaching. The objective is to address internal issues of work allocation, satisfaction at work, cultural affiliation, wellness and wellbeing.
<p>The European Commission's Accounting Officer has notified the JU of the intention to terminate the role of Accounting Officer of the JU, except for the treasury function. This was linked to the provisions of the establishment of the Back Office Arrangements (BOA) between the JUs in accordance with the SBA. There is a risk that the qualitative work performed by the Commission Accounting Officer will not be so easily replaced by the BOA, as it requires skill and competence that are scarce and limited within the EU-Rail as well as overall in all JUs. There is a risk that the transition process and ramp-up phase of the new function would jeopardise the reporting cycle and legal obligations of the JU.</p>	<ul style="list-style-type: none"> - Set up with the other JUs without delay the new Accounting Officer function within the BOA. - Outsource the accounting activities, for example, to private companies which can also sign off the accounts, while keeping in house the Accounting Officer.

Risk identified	Action plan
<p>Inadequate timing of the new legislative framework for EU-Rail becoming effective led to having more than 1 year without calls for proposals for the new Programme under Horizon Europe.</p>	<ul style="list-style-type: none"> - Preparation of the new templates documents related to the running of the programme under Horizon Europe. - Keeping all staff informed on the current developments and re-prioritising of tasks and activities, if needed, in order to successfully execute the transition. - Ramp up the programme with the objective to ensure effective implementation of R&I Projects and System Pillar Tasks during Q4 2022
<p>Absence of proposals of EU-Rail's members and/or other beneficiaries in the first call, or their failure to submit proposals in time or in adequate quality, due to process changes under the new Programme, potentially resulting in the need to re-launch calls and having the research and innovation activities started with delay.</p>	<ul style="list-style-type: none"> - Regular circulation of information regarding the procedures of the new Programme and the Horizon Europe rules. - Intended advanced publishing of the 2022 Annual Work Plan (in draft version) in order to allow everyone to get familiar as soon as possible with the potential topics of the first call.
<p>Being a new element under the new Programme, and given the related possible cautious approach of the industry sector, the System Pillar might have a slower start with regard to the adoption of a system architecture and reflection on European-based operational concepts. This might result in the misalignment between the Innovation Pillar (R&I activities) and the system integration approach.</p>	<ul style="list-style-type: none"> - Timely launch of the ramp-up phase for the System Pillar. - Timely involvement of sector associations. - Assurance of continuity provided through the Steering Process of the Commission.
<p>Impediments emerging during the project lifetime (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 the JU's solutions from reaching the market.</p> <p>This may in particular include force-majeure events (e.g. COVID-19) of longer duration which may lead to difficulties in obtaining the necessary authorisation(s) to organise project demonstrations, resulting in non-completion of such activity in the project concerned.</p>	<ul style="list-style-type: none"> - Ensure appropriate implementation/exploitation plans in GA and at TD/IP level, as well as via national migration strategies. - Investigate possible instruments to support deployment at EU-level and implement JU strategy/support. - Regular follow up of JU's standardisation roadmaps. - Coordination with RASCOP, and also directly with ERA, CEN/CENELEC/ETSI + regular follow up at IPSteCo/SIWG + regular updated with EURID WG. - Follow-up on regulatory framework developments. - Change management approach (EDPB). - Continuous risk management and risk response (e.g. regular Covid risk assessment at project level). - Revisions of WP/MAWP/MP.

Taking into consideration that a new membership was established with the new partnership and the first Tasks and Projects will run as from year end, a new encompassing risk management exercise will be performed by the end of 2022 – early 2023 in view of the next Work Programme.

2.3.7 Scientific priorities, challenges and expected impacts

The focus of EU-Rail's Programme as per particular Tasks, Flagship Areas and the Transversal Topic is presented in Section 2.3.1. Specific details on the scientific priorities are provided in EU-Rail's MAWP.

The most relevant challenges that the future rail system needs to address are defined in EU-Rail's MP.

They can be grouped in several topics as follows:

- **Changing customer requirements**
Political, demographic, technological and market trends are changing the needs of passenger and freight rail customers. These shifts, along with disruptive events like the COVID-19 pandemic, require rail to be more flexible than in the past. A customer-centric rail system means offering reliable services that are reactive to demand, adaptable to customer requests, and accessible for all passengers alike.
- **Need for improved performance and capacity**
In order to deliver an overall more sustainable transport system, rail must be able to accommodate increased demand. New infrastructure will be necessary in certain areas, but the vast bulk of future increased capacity must leverage existing infrastructure, through a systemic digitalization and automation of operations.
- **High cost**
Rail is currently often more expensive compared to other transport modes, in some cases reflected on the intermediaries or passengers/users. To be more competitive and support future increased usage, rail must deliver more cost-efficient solutions and services when compared to the present day.
- **Climate change adaptation and environmental sustainability**
Rail is the most sustainable form of motorised transport. Increased use of rail is necessary to fulfil the goal of introducing European climate-neutral mobility and transport. In addition, steps have to be taken to further improve the climate and environmental footprint of rail itself (e.g. reduce the noise). Rail services and networks must also become more resilient against the impacts of climate change.
- **Legacy systems and obsolescence**
Rail system assets have very long lifecycles and are based on global and European requirements; additionally, legacy national requirements still survive. The incompatibility of certain national requirements between EU Member States in conjunction with long life cycles results in market fragmentation, greater complexity in introducing new functions in a coordinated way, and in a significant increase in costs. Rail must move to common European network with stronger implementation of the objective of having an increasingly integrated Single European Rail Area, and be more flexible to introduce and scale up new technological and operational solutions to deliver new and improved client oriented services.
- **Interaction with other modes**
Rail networks, and the services associated to them, to a certain extent link well with other transport modes. But such integration must be improved to better serve the needs of customers, and to make rail a more attractive mode overall so that it can become central to future mobility.
- **Increased competition**
The European rail supply industry is world leading. However, it faces many challenges at global level. Innovative solutions, conceived, designed, and developed jointly creating new products to be deployed at European level are necessary to strengthen the competitiveness of the European rail supply industry, including its SMEs, providing major opportunities for system integrated solutions to be deployed at global level.

By making efforts in addressing the above-mentioned challenges of rail, and by delivering its set objectives, EU-Rail will strive for the following impacts:

- **More flexibility and punctuality for passengers / freight**
EU-Rail will support the delivery of much more flexible approaches to planning and traffic management of rail services, allowing rail to better serve customer needs.
- **Improved performance and capacity**
Through the development of cutting edge technologies designed to be implemented across the whole EU rail network, EU-Rail will help increase capacity and make best use of available assets.
- **Reduced costs**
EU-Rail outputs are expected to help improve the efficiency of the rail system and reduce overall lifecycle costs, including on the less used lines.
- **More sustainable transport**
EU-Rail will contribute to a more sustainable transport and mobility system by enabling an increase in the use of rail services, and improving the sustainability of the rail sector itself.
- **Harmonised approach to evolution and greater adaptability**
EU-Rail will support the sector in coordinating on a common evolution of the system, and a greater harmonisation to support the delivery of the Single European Rail Area and improve the rate of deployment of new technologies.
- **Reinforced role for rail in European transport and mobility**
EU-Rail work will support smart and cost-efficient rail connectivity, key to future sustainable mobility systems, to deliver better services for passengers and freight.
- **Improved EU rail supply industry competitiveness**
Increasing the R&I intensity of the European rail supply industry will enhance its capacity to retain its global leadership. By supporting the transformation of the current rail system into a central transport mode of tomorrow's European mobility, EU-Rail will build unique capabilities in the European rail industry, supporting its position in global markets.

2.3.8 Calls for proposals

The below table, summarizes the values of the operational activities planned in 2022 under EU-Rail/Horizon Europe, including the different calls (in 2022 commitment appropriations):

Year 2022	Type of call	Value of the actions	Maximum EU-Rail co-funding	Non-funded activities	Target contributions from Members in case of award	Indicative publication date
Multi-annual Call for Proposals (*)	Open	390.0	234.0	156.0	302.0	Q1
	2022 values	226.2	135.7	90.5	175.1	
Call for Proposals– Exploratory Research	Open	14.5	12.5	2.0	4.3	Q3

- (*) this call for proposals will be launched implementing multi-annuality by instalment, meaning that the amount committed by the JU will be confirmed yearly based on the annual budget of the JU. For more information about the annual instalments, please refer to the “Table of Financial programming per year until 2027” in the chapter 3 Budget 2022-2024 of the present document

In accordance with the SBA and HE, EU-Rail makes use of calls for tenders to implement the R&I Programme, performing studies, seeking for professional support and expertise to the partnership, and any other relevant activities requested by the Governing Board to complement other R&I activities. For clarity, in line with previous years’ decisions of the Governing Board, these calls for tenders are not intend to replace functions entrusted to the Programme Office although from the pure accounting point of view, some costs are accountend in administrative lines of the general ledger.

2.3.8.1 Conditions of the calls and calls management rules

The first EU-Rail Call 2022 follows the rules of the European Union’s Horizon Europe framework programme and in particular the Horizon Europe rules for participation¹⁶ as well as the General Annexes to the HE Work Programme 2021-2022¹⁷, which apply, unless specified otherwise, to EU-Rail calls for proposals.

Regarding admissibility conditions and related requirements, part A of the Horizon Europe Work Programme 2021-2022 General Annexes applies with the following exception: the limit for a full Innovation Action application is set to 120 pages.

Part B of the Horizon Europe Work Programme 2021-2022 General Annexes applies for general eligibility conditions.

As regards to financial and operational capacity, part C of the Horizon Europe Work Programme 2021-2022 General Annexes applies.

Part D of the Horizon Europe Work Programme 2021-2022 General Annexes applies regarding the award criteria, scores and weighting upon which the proposals will be evaluated, with the following addition:

- Under the criteria “Excellence”, “quality of the proposed joint activities to achieve the deliverables”
- Under the criteria “Impact”, “quality and credibility of the action to contribute achieving the EU-Rail Master Plan objectives and the expected impact of the EU-Rail Multi-Annual Work Programme”.
- Under “quality and efficiency of the implementation”, “Appropriateness of the project management structure and quality of the proposed coordination”.

With regard to the mandatory documents and annexes to be uploaded in the submission system, Part E of the Horizon Europe Work Programme 2021-2022 General Annexes applies.

Part F of the Horizon Europe Work Programme 2021-2022 General Annexes applies in regard as to the type of the one-stage evaluation procedure and other aspects such as budget flexibility, joint/coordinated calls, indicative timetables for evaluation and signature of the grant agreement(s) and the evaluation review procedure if a complaint is submitted.

¹⁶ <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018PC0435>

¹⁷ https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2021-2022/wp-13-general-annexes_horizon-2021-2022_en.pdf

Part G of the Horizon Europe Work Programme 2021-2022 General Annexes applies in regard to legal and financial set-up of the grant agreements, which includes aspects such as starting date, deliverables, form of grant, maximum grant amount and budget categories.

The funding rate for each grant is set at 60% of the total eligible costs for innovation actions (IA); each Consortia may decide internally different funding rates in line with the provisions of Article 34 of Horizon Europe nevertheless complying with the overall funding rate of 60%.

Considering the lessons learned from the implementation of lump sum pilot since 2018, including evaluation and first reporting periods, EU-Rail Calls for proposals will take the form of lump sums as defined in Commission Decision https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lis-decision_he_en.pdf.

In order to facilitate the contribution to the achievement of EU-Rail objectives, the option regarding 'linked actions' of the Horizon Europe Model Grant Agreement and the provisions therein, will be enabled in the corresponding EU-Rail Grant Agreements. Complementarity between particular topics is specified within their scope, in Annexe VII of this Work Programme.

Considering the strategic interest of the expected outcomes of actions funded under this call, EU-Rail JU reserves the right to object to transfers or licensing up to four years after the end of the action, in accordance with the conditions set in Annex 5, Article 16 - *Granting authority right to object to transfers or licensing*, and Article 18 – *Specific rules for carrying out the action – Specific rules for JU actions*.

The outcomes of actions funded under this call are also expected to contribute to European or international standards wherever possible (refer also to Art. 16 – *Exploitation of results* – in Annex 5 of the Horizon Europe Model Grant Agreement). In this respect, the actions are also expected to contribute to the development of EU policies and legislation (including Technical Specifications for Interoperability and Common Safety Methods), System Pillar documents, and in this respect the granting authority, the European Commission, European Union Agency for Railways and the other bodies will require access to the relevant results (i.e. proposals for specifications, requirements, etc.) in accordance with the provision of Annex 5 of the Horizon Europe Model Grant Agreement – Article 16 - *Access rights for the granting authority, EU institutions, bodies, offices or agencies and national authorities to results for policy purposes – Horizon Europe actions*.

Regarding the dissemination obligations of the actions that will be funded under this call, considering that the actions contribute in an integrated manner to the achievement of the EU-Rail objectives established in Council Regulation (EU) 2021/2085 and the Master Plan, there is a need to ensure that also the dissemination activities - participation to fairs, mid-term and final events, social media, etc. – are consistent and coherent with the EU-Rail Communication and Dissemination Strategy, expected to be adopted by the Governing Board by mid-2022. Consequently, the actions shall plan, design, coordinate and contribute to the EU-Rail Programme Communication and Dissemination activities, in agreement with the Stakeholder Relations and Dissemination structure of the JU. This additional exploitation obligation starts from the design of the dissemination and communication activities in the proposal phase; it is established in accordance with Annex 5 art. 17 - *Additional dissemination obligations*.

As regards private members and their constituent or affiliated entities established in third countries, the interests of the Union and the joint undertaking on the grounds of security or public order should be safeguarded. To that end, the JU should be able to request private members to take appropriate measures. Such measures could include the appropriate handling of confidential information or limitation of certain entities in specific operational activities of the private member as stated in recital 16 of Council Regulation 2021/2085.

2.3.8.2 List of countries entrusting the JU with national funds for the calls 2022

During 2022, EU-Rail was not entrusted by any country with national funds.

2.3.8.3 Country specific eligibility rules

The conditions are described in part B of the General Annexes to the Horizon Europe Work Programme 2021-2022 are applied by EU-Rail without exceptions.

2.3.9 Calls for tenders and other actions

In 2022, EU-Rail is planning to implement the following call for tenders within framework of the MAWP:

Procurement procedure	Title	Scope	Indicative timetable (Q-quarter)	Indicative budget (EUR)
Open procedure – framework contracts for services	Europe's Rail System Pillar	The Europe's Rail Joint Undertaking will launch a call for tender for a single framework contract (one per lot) to perform the activities established in the Council Regulation (EU) 2021/2085 for the System Pillar (Articles 91 and 96). The call for tenders will be divided in 3 lots. The contractor(s) shall : 1) provide expertise with system engineer knowledge developed in rail or other fields, which collectively represent the main stakeholders of the rail sector; 2) deliver the work defined initially in the report of the European Commission on the System Pillar of July 2021 as well as in the Europe's Rail Master Plan and the Multi Annual Work Programme; 3) ensure that the current and	Q1 2022	45 000 000 (Specific contracts 2022: 10 000 000)

Procurement procedure	Title	Scope	Indicative timetable (Q-quarter)	Indicative budget (EUR)
		future CCS TSI specifications (in line with, but not restricted to, the evolution of the research and innovation activities of Europe's Rail) are properly maintained to be able to introduce innovative solutions.		
Open procedure – framework contracts for services or other procedures provided for in the EU-Rail regulation	Project management	The Europe's Rail Joint Undertaking will launch a call for tender or other procedure provided in the Financial Rules for one or more contract to set up a dedicated management structure for projects asnd foster synergies with other programmes, European, national, regional, etc.	Q2 to Q4 2022	3 600 000 (Specific contracts 2022: 900 000)
Open procedure subject to assessment to become a Call for Proposals	Bridge Dynamics	Development of new calculation methods and recommendations / adjustments on current methodologies / bridge factors for bridge dynamic parameters (based on available knowledge and on a the CEN related procedure for the evaluation of the dynamic behavior of the bridges during train passage using the DER method and the time step integration calculation (TSC) for a set of representative bridges together with representative train data)	Q2 2022	300 000
Open procedure	IT Tools for TT Digital Enablers	Non-railway generic IT tools and concepts to support the expected	Q2 2022	2 000 000

Procurement procedure	Title	Scope	Indicative timetable (Q-quarter)	Indicative budget (EUR)
		outcomes of the TT destination as described in the MAWP: implementation and adaptation of generic IT technology and concepts, that are used (not developed) and adopted to support a respective railway application and its needs. (E.g. communication protocols (TCP/IP), data encryption/compression, visualization, service API specification and/or cloud technology in general that might be used within the EU-Rail Flagship Projects). Expected output will include at least Digital Twin Design time environment; Digital Twin Run time environment; Data Assets Registry, Discovery and Distribution Services.		
Framework contract's implementation	Strategic support to the EU-Rail and other studies (*)	Implementation of a 4-year framework contract (following an open call for tenders procedure) with a total value of EUR 2.3 million.	Q1 to Q4 2022	400 000
Framework contract's implementation	Functional system architecture–	Implementation of a 2-year framework contract (following a middle value contract procedure) with a total value of EUR 130 000	Q1 to Q4 2022	40 000
Framework contract's implementation	Railway operators, staff and passengers expertise	Implementation of a 4-year framework contract (following an open call	Q1 to Q4 2022	60 000

Procurement procedure	Title	Scope	Indicative timetable (Q-quarter)	Indicative budget (EUR)
		for tenders procedure) with a total value of EUR 2 million.		
Total		Value of commitments for 2022		13 700 000
Framework contract's 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 (following an open call for tenders procedure) with a total value of EUR 11 million, amount under a L1 commitment of 2021	Q1 to Q4 2022	2 900 000
Total		Value of commitments of 2022 and previous years		16 600 000

Open procedure – framework contracts for services or other procedures provided for in the EU-Rail regulation	Europe's Rail European DAC Delivery Programme (EDDP)	The Europe's Rail Joint Undertaking will launch a call for tender or other procedure provided in the Financial Rules for one or more contract to continue the management and coordination activities of the European DAC Delivery Programme, enabled by Europe's Rail (sector-wide platform management and alignment tasks in particular in relation to DAC deployment planning, use cases, CBA principles.)	To be launched in Q3/2022 under the 2023 budget appropriations	p.m. [1 600 000 excluding additional specific studies and analysis if needed; (4 years: 2023-2026) (Specific contracts 2022: 0)]
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As already indicated, in accordance with the SBA and HE, EU-Rail makes use of calls for tenders to implement the R&I Programme, performing studies, seeking for professional support and expertise to the partnership, and any other relevant activities requested by the Governing Board to complement other R&I activities. For clarity, in line with previous years' decisions of the Governing Board, these calls for tenders are not intend to replace functions entrusted to the Programme Office although from the pure accounting point of view, some costs are accountend in administrative lines of the general ledger.

2.3.10 Follow-up activities linked to past calls: monitoring, evaluation and impact assessment

With the beginning of 2022, most of the S2R JU's ongoing projects governed by the Horizon 2020 rules, are getting to the late stages of their lifecycle. The latest S2R Projects are expected to be phased out between 2023 and early 2024.

The ongoing projects are subject to continuous monitoring and evaluation to follow-up on their progress and also to be able to deal with different elements which may influence a demonstration to take place (e.g. necessary authorizations).

Table I of Annex IV presents the current impact assessment of ongoing projects using the set of KPIs originally defined for S2R:

- 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).

These indicators were design as a monitoring tool to ensure that the S2R Programme research and innovation activities aimed to contribute achieving them, not necessarily reaching them.

In addition, these originally identified KPIs are dependent on segments and implementation in a situation that is evolving with the evolution of the research and innovation. Hence, the impact introduced by the results of the S2R Programme might be less visible as many of the technological components developed in critical areas of the Programme do not wait the final project end to be deployed, but they are already introduced in the successive release of products.

It appears clearly from the Table that the S2R Programme has performed its activities substantially contributing to the targets and, consequently, setting an opportunity for the future deployment of innovative solutions making rail more competitive, resilient and reliable.

As already indicated, the current overview of demonstrators for S2R projects with a Technology Readiness Level (TRL) reaching at least value 6 (technology demonstrated in relevant environment), is displayed in Table II of Annex IV, together with the provisional planning for test end.

The specific details on how the outputs and achievements of the past or ongoing Shift2Rail projects will be applied for EU-Rail's research and innovation are provided per each Flagship Area and the Transversal Topic in the MAWP.

2.3.11 Cooperation, synergies and cross-cutting themes and activities

EU-Rail will strive for maximising its impact using also synergies with other European, national and regional programmes and activities. Beyond the involvement in the overall coordination of Horizon Europe, the JU will in particular focus on capturing synergies across the following:

Synergies within the “Climate, Energy and Mobility” cluster: EU-Rail will reach out to other mobility JUs with the aim to build, where possible, consistent projects and demonstrators for climate neutral mobility solutions. This may also address shared areas of intervention such as multi-modal transport, automation in vehicles and other assets, decarbonisation, use of alternative fuels, etc. In particular, specific coordination with the European Partnership for Clean Hydrogen, as well as with the Battery co-programmed partnership appear to be of key relevance.

Synergies with the “Digital, Industry and Space” cluster: Considering the key challenges related to the digital transformation of rail, there are major expectations on how this cluster would be contributing with rail-critical applications. Artificial intelligence, cyber-security and high-performance computing are cross sectoral issues that require deep coordination especially for the development of use cases and the application of European standards. In addition, European space policy appears to be of key relevance, considering the ambition to introduce more and more satellite-based solutions for localization or data transmission. Here also synergies with EUSPA will be continued building upon the past experience.

Synergies with the Co-Programmed Partnership on AI, Data and Robotics, which could support access to such technologies and relevant industrial partners and developers will be considered in the implementation of this Work Programme. Additionally, inspection and maintenance was one of the 4 priority areas defined under the robotics PPP, so there is knowledge to build on, notably project RIMA, the network of Digital Innovation Hubs for I&M. In addition, EU-Rail will ensure the collaboration with the ongoing 5Grail Project in relation to FRMCS, which constitutes one of the enabler of rail digitalization and automation.

Synergies with EU Missions: EU-Rail will explore joint activities with the Climate-Neutral and Smart Cities Mission contributing to comprehensive climate-neutral and smart urban mobility solutions. Single ticketing and smart transport hubs integrating sub-urban and long-distance passenger rail traffic with urban mobility are possible areas of collaboration.

Coherence and synergies in relation to major national (sectoral) policies, programmes and activities:

It is estimated that around 15% of the EU stimulus package called Recovery and Resilience Facility - RRF- will be invested in different areas of rail national systems. There is a need to ensure maximum levels of complementarity and impact, including focusing on future-proof investments. This will require to leverage local, regional and national investments to complement the research and innovation activities performed at EU-Rail level and vice versa. In this respect, the States Representatives Group is expected to play a key role.

In carrying out its activities, EU-Rail will seek to establish the necessary international connections in relation to rail research and innovation, in line with the Commission priorities. In this respect, the JU will cooperate with third countries and/or international organisations, in particular to contribute to the competitiveness of the European rail industry at global level.

EU-Rail will continue the cooperation started by S2R JU with a number of key international partners, such as FRA, APTA, FTA in the US, CUTRIC (CA), Gulf Countries and India. In line with the policy priority of the Commission in terms of rail international relations, it is also expected that exchanges will take place with ASEAN, Australia, Japan and Mexico.

The collaboration with the EU neighbouring countries, in particular Western Balkans, will continue with the aim to further explore the opportunities for joint activities and large scale demonstrations.

2.4 Support to Operations of EU-Rail in 2022

2.4.1 Communication, dissemination and exploitation

Communication

In order to ensure strong engagement from a wide range of stakeholders, communication must be truly integrated into the overall framework of the EU-Rail Programme and it is intrinsically related to the knowledge of the membership, the rail sector and its stakeholders.

Building upon the experience of the European Year of Rail and the Connecting Europe Express, where the former S2R reached out to Ministers, Mayors, Governors and citizens of more than 30 countries during a European connecting rail journey, communication on the JU's results and their impact on citizens' everyday lives will be one of the focus points of the EU-Rail's efforts in 2022.

Ensuring that the objectives of the new Programme are well understood by the community is fundamental to have the necessary buying in to prepare since the beginning for the future deployment of results. Actions in this area aim to support and demonstrate the added value of the ongoing R&I activities as well as to inform on the new Programme to be launched under Horizon Europe. To support the establishment of the new Europe's Rail JU, a new branding and visual identity (new logo, revamping of the website and social media) will be introduced to the stakeholders. To that effect, a stakeholders' analysis exercise will confirm the existing audiences for EU-Rail and identify new potential partners who will be invited to join the EU-Rail community.

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.

The current communication strategy will be update by 30 June 2022, once the objectives for the communication activities have been identified jointly with the JU's new Members.

EU-Rail communication activities aim to:

- **Continue to raise awareness about the JU** among key stakeholders across Europe from the rail sector and beyond, given the ambition of a better integration of rail with other transport modes for both passengers and freight managers, and the need to establish bridges with other thematic areas and sectors as identified in the EU Green Deal.
- **Support and promote the recognition of the JU's 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 new key priority areas and adaptation of key messages to each stakeholder.
Both of the two aforementioned objectives will require close work with different stakeholders and their associations.
- **Promote the JU within the EU Institutional arena.** This objective consists of maintaining and further developing political support for EU-Rail from the EU institutions and EU Member States through the promotion of the JU, its objectives and achievements. Target audiences for this objective include the European Parliament and/or the Council (with particular attention to the rotating presidencies) and policymakers in EU Member States, the Committee of the Regions, the European Economic and Social Committee and other EU bodies, such as the European Union Agency for Railways (ERA), the European Environmental Agency (EEA) and other Joint Undertakings. 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. It is essential to maintain efficient communication channels with DG MOVE and DG RTD and explore all possible collaboration with other DGs, EU Agencies and bodies (ERA, other JUs) where appropriate to further increase synergies between EU policy areas and rail transport. EU-Rail will also build synergies with other transport focused Joint Undertakings through joint initiatives to further reinforce the collaborative message.

- **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 EU-Rail website as well as providing information to projects on Horizon Europe dissemination tools. This will include assisting the projects to disseminate their results through the JU's newsletter and social media channels, and providing guidelines to the projects on issuing coherent communication products and activities in line with the JU's corporate branding and messages.
- Pro-actively **publish communication material** with regard to external events and meetings related to the EU-Rail. A broad dissemination of factsheets, leaflets, reports and brochures will enhance the visibility of the 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 EU-Rail's activities.
- **Manage the EU-Rail website, newsletters and social media platforms** in order to stimulate the public interaction on key issues and improve public awareness on the JU's activities, and issue the corporate and visual identity of the new JU. To that effect, a bi-annual meeting will be set-up with the Communication officers of the Members to identify joint communication activities and channels, and in particular, this year, to elaborate the presence of the JU at major events such as Innotrans. Regarding branding, the new Members have been invited to contribute to the creation of a logo for the new JU, building on the existing branding but adding, through the visuals, the new objectives of the JU based on the three pillars identified in the Multi-Annual Work Programme.

Further to the above, EU-Rail will rely on key multipliers:

- JU Members, including JU project coordinators, corporate Communication managers and project participants, who will communicate the success of the JU to various audiences;
- ERRAC members, including policy makers and decision-makers;
- Members of the Scientific Committee (SC);
- Local stakeholders;
- Members of the States Representatives Group (SRG);
- Wider stakeholders reached through EU-Rail 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;
- EU-Rail 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. EU-Rail works in collaboration with other JU's to secure a joint framework contract for communication services. The outcome of the tender should be made public by the end of February 2022 at which date, communication activities can be requested to the external providers.

Dissemination

The results of the ongoing activities and of projects/tenders will be disseminated by EU-Rail via its website (the platform for Railway R&I), press releases, newsletters, presentations at internal (EC, Governing Board, Scientific Committee, States Representatives Group) and external (conferences, Info days, etc.) stakeholder events, and through social media.

EU-Rail 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 Europe 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.

The main events, where EU-Rail will showcase its results in 2022, are the World Congress on Railway Research 2022 (Birmingham 6 – 10 June), InnoTrans 2022 (Berlin 20 – 23 September) and the Transport Research Arena (TRA) 2022 (Lisbon 14 - 17 November). The preparations for the 2023 EU-Rail Innovation Days will be performed in Q4 2022. These key events will require to converge substantial budget dedicated to Communication activities and missions.

Exploitation

Although S2R Programme has already contributed to shortening of the innovation cycle in rail via an integrated research and innovation programme, EU-Rail is expected to accelerate further the introduction of innovative solutions. In order to deploy novel solutions, the sector needs to move towards new ways of working enabling the transformation of rail as one European integrated system.

Only via a coordinated and integrated deployment of system integrated solutions can rail reap the benefits of the investments made, accelerate its transformation and deliver new services to its clients.

In the past years, the deployment of innovative solutions has too often resulted in a patchwork system, where the intrinsic benefits of investments were lost and even resulted in additional costs as, in many cases, such solutions have been deployed as additional layers to existing systems. This resulted in an increase in the maintenance costs, in additional complexities, in a lack of trust in the new solutions and, de facto, has anchored Europe rail systems to their legacy, missing the opportunity for a major transformation.

There is a clear and shared sector vision that accelerating the deployment of future technological and operational solutions requires decisions that will shape also the execution of the future EU-Rail projects and a different approach: where the introduction of innovative solutions has a clear impact on rail in its systemic nature, deployment shall be coordinated and consistent to accelerate the return on investment and phase out legacy products. This new way of working shall be based on more flexibility and adaptability to user needs, creating solutions much more focused on prototyping and large scale demonstrations, and increased collaboration integrating new entrants, leading to a shorter innovation cycle and delivering impactful results.

Basic considerations regarding exploitation and deployment of results of R&I activities as per each Flagship Area and the Transversal Topic are included in EU-Rail's MAWP.

In terms of the market uptake of the future rail R&I solutions and their deployment, the SBA foresees an important role of the Deployment Group as an advisory body to the Governing Board. Its tasks are detailed in Section 2.5.6.

2.4.2 Procurement and contracts

In order to reach its objectives and adequately support its operations and infrastructures, EU-Rail 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, EU-Rail makes use of Service Level Agreements (SLAs) concluded with relevant Commission Services and inter-institutional framework contracts (FWCs) available to them.

In 2022, EU-Rail foresees to run several procurement procedures for middle or low-value contracts¹⁸, to implement existing FWCs and to select individual external experts based on a call for expression of interest (CEI).

Title	Indicative budget (EUR)	Type of procedure	Indicative schedule (Q-quarter)
Communication and event services and supplies	550,000	Middle or low-value contracts or specific contracts/order forms implementing a FWC	Q1 to Q4 2022
Subscriptions to journals & periodicals	10,000	Negotiated procedure for low-value contracts	Yearly
Assistance and support of external experts	50,000	Ad-hoc expert contracts, not for call evaluation nor review, based on a CEI	Q1 to Q4 2022
Basic Office Furniture	<15,000	Specific Contracts/order forms implementing a FWC	Q1 to Q4 2022
Catering services	35,000	Low-value contracts or specific Contracts/order forms implementing a FWC	Q1 to Q4 2022
IT support and supplies	150,000	Specific Contracts/order forms implementing a FWC or Negotiated procedure for middle or low value contract	Q1 to Q4 2022
Team Building and Training	20,000	Negotiated procedure for low value contract or Specific Contracts/order forms implementing a FWC	Q1 to Q4 2022
Finance and audit	25,000	Specific Contracts/order forms implementing a FWC	Q1 to Q4 2022
Legal Assistance	50,000	Specific Contracts/order forms implementing a FWC	Q1 to Q4 2022

This list shall not be considered exhaustive and other procurement procedures may need to be launched within the budgetary limits approved by the EU-Rail Governing Board and the budget flexibility clause. The Executive Director shall report to the Governing Board about the procedures put in place as part of the AAR 2022.

2.4.3 Other supporting operations

As indicated in the SBA, potential synergies and efficiencies with other Joint Undertakings could be gained through the set-up of back office arrangements between the European Institutional partnerships in areas such as HR legal, IT, communication, accounting, audit and anti-fraud strategy and logistics/events/room management. Joint undertakings shall, within one year following the date of entry into force of the SBA, operate back office arrangements by concluding service level agreements, subject to the need to guarantee an equivalent level of protection of the Union's financial interest when entrusting budgetary implementation tasks to joint undertakings. Such arrangements are subject to confirmation of viability and following screening of resources.

¹⁸ In accordance with Article 43(2) of the EU-Rail's Financial Rules, for contracts with a value between EUR 60 000 and the thresholds laid down in Article 175 of Regulation (EU, Euratom) 2018/1046 the procedures set out in Section 2 of Chapter 1 Annex I to Regulation (EU, Euratom) 2018/1046 for contracts with a value not exceeding EUR 60 000 may be used.

The JUs' Executive Directors have already started working together on such arrangement, which shall include at least the areas included in Article 13 SBA, subject to confirmation of viability and following screening of resources. It will largely enhance and make systemic the practices already in place between the JUs since several years in the areas of ICT, joint institutional events, logistic, data protection, joint procurements.

2.4.3.1 IT activities

EU-Rail has implemented common ICT tools designed and offered by the European Commission on the financial management, human resources management and HE call management. These tools are updated and maintained on a regular basis by the EC; they require continuous input from the side of the 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. To be noted that at the moment of the preparation of this Work Programme, the JUs seem not to benefit from all the features available, increasing the need for manual interventions and ad hoc solutions. One of the key examples is that the introduction of Lumps Sum Grants, the submission of financial data for budget proposals is still done via excel tables.

Since 2018, the 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 has implemented SYSPER for staff administration in 2019, thereby leveraging on the existing EC infrastructure and processes. In addition, EU-Rail is making use of the trainings dedicated to these applications offered by the EC, to assure their correct usage and implementation by its staff.

In 2022, EU-Rail will start using SYSTAL, a tool provided by the EC to manage the staff recruitment.

EU-Rail shares its ICT infrastructure with other Joint Undertakings located in the White Atrium building. In order to provide for an improved security, availability of the systems and staff mobility, the physical infrastructure was virtualized in 2017 to a private cloud platform. Since 2019 this service falls under the inter-agency cloud framework contract led by EFSA in Parma. Another example of collaboration is the tool for the management of the GDPR Register which EU-Rail has procured also on behalf of the other JUs, and which has been in use since 2020.

Following the Data Protection Impact Assessment (DPIA) conducted in 2020, the JUs started to migrate to Microsoft cloud services (M365) in 2021, to deliver an improved collaborative environment in combination with an even higher level of ICT security. EU-Rail will continue with the migration to M365 in 2022.

EU-Rail collaborates with the other JUs in synergy under a joint strategic ICT plan. This plan includes for 2022 the renewal of the contract for ICT managed services via a call for tenders; the migration to Exchange online and to the Microsoft Identity Manager (MIM) to ensure seamless bridging multiple systems; the implementation of a third-party backup for the M365 services and the setup of a fully featured videoconference system in a common meeting room.

2.4.3.2 Data protection

As regards the processing of personal data, EU-Rail applies Regulation (EU) 2018/1725 of 23 October 2018¹⁹, which entered into force on 11 December 2018.

¹⁹ 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 role of the Data Protection Officer (DPO) is exercised by the EU-Rail's Chief Legal Officer assisted by an external contractor since early 2021.

EU-Rail, as a controller, maintains a record of processing activities under its responsibility in a central register (GDPR central) and makes this register publicly accessible. In addition, EU-Rail takes appropriate measures to provide transparent information, communication and modalities for the exercise of the rights of the data subject. A collection of privacy notices for each specific processing operation is available in the EU-Rail website.

More information is available on the EU-Rail data protection and legal notices pages²⁰.

2.4.3.3 Accounting

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

EU-Rail implements its financial rules which define, inter alia, powers and responsibility of EU-Rail's Accounting Officer. They also make an explicit reference to the possibility that this function could be attributed to the Accounting Officer of the EC, and such option was effectively utilised by the JU.

However, in October 2021 DG BUDG announced the intention to terminate their role of the Accounting Officer of the JU, now confirmed to be effective as of 1 December 2022, except for the treasury function. This decision was linked to the foreseen establishment of the back office arrangements between the JUs in accordance with the SBA. This situation represents a risk of jeopardising of the JU's reporting cycle and its legal obligations, as replacing the EC Accounting Officer by the back office arrangements may not be without difficulties, especially with regard to the fact that the necessary skills and competence are scarce and limited within EU-Rail, as well as overall in all JUs. EU-Rail will seek with the other JUs how to deal with this challenging situation.

2.4.4 Human resources

2.4.4.1 HR management

In 2022, EU-Rail shall be staffed with 29 staff members including 2 Seconded National Experts (SNEs). In line with the new Establishment Plan, recruitment procedures will be launched in the course of the year in order to gradually recruit the additional staff members as well as vacant positions due to inter-agency mobility. Where needed, the JU will make recourse to Contract Agents (CAs) to cover long-term absences as well as to Interim Staff. In addition to statutory staff members and the SNE's already in place, the EU-Rail will also make use of the European Commission's Bluebook to hire trainees.

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

The EU-Rail HR function will continue to ensure ongoing improvement of all HR processes and to develop its internal guidelines, policies and its legal framework, paying particular attention to how EU Staff Regulations' Implementing Rules shall apply to the 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 EU-Rail Financial Rules.

²⁰ <https://shift2rail.org/terms-of-use/>

The JU will continue to implement its action plan resulting from the staff survey conducted in 2020 which was built on three main pillars:

- a. Review of the processes implemented, including in view of the new R&I Programme;
- b. A “well-being” year-long programme, including to support staff, collectively and individually, during the pandemic;
- c. A dedicated training programme to re-think the corporate culture of the organization.

A new staff survey will take place in 2022 with a view to assess the evolution compared to the results of the previous one.

In addition, following the remote working experience due to the Covid-19 constraints, and subject to any new Implementing Rule adopted by the Commission in this respect, EU-Rail will on an ongoing basis strive for finding appropriate balance between working at the office and remote working. The office space will be designed to accommodate the new staff within the current premises.

2.4.4.2 Strategy for achieving efficiency gains and synergies

In 2022, the JU’s major challenge will be to ensure a successful and smooth transition towards the new EU-Rail Programme.

From an HR perspective, EU-Rail is committed to ensuring the well-being of staff and that every staff member reaches their full potential. Trainings are strongly encouraged and staff events are organised on regular basis in order to reinforce the cohesion of the team, the staff engagement and motivation.

Following the 2020 staff survey, the JU started to review its processes with the support of a consultancy company and it has defined 4 main HR areas to work on:

- Develop a future-proof competency framework to guide recruitment and sourcing of expertise;
- Establish a sourcing strategy for ensuring optimal delivery of services with limited resources;
- Establish a talent development plan to provide perspective and training;
- Revamp the approach to performance management focusing on evidence-based recognition and reward.

The next step will be to define priorities among these topics and progressively develop an action plan for each one of them.

Also, in 2022, in view of the arrival of the new colleagues, a new and more contemporary office set-up will be created inspired by DG HR’s model to ensure an efficient and safe work environment. Provision of proper facilities for teleworking and optimizing the space available in the premises are additional goals of this new office set-up.

In terms of synergies and collaboration with the other Joint Undertakings, in 2022, the JUs will continue sharing the HR-related IT tools (e.g. the e-recruitment tool SYSTAL, SYSPER) and, where necessary, common calls for tender, selection procedures, training courses for JUs staff and managers as well as a common approach to implementing rules of the EU staff regulations. In addition, EU-Rail will continue sharing information and best practices with the other JUs through meetings and working groups e.g. the Executive Directors, Heads of Administration, HR officers, legal officers etc. and meet regularly to discuss and share experience and best practices. Moreover, in line with the hybrid way of working, further synergies among JUs will also be possible in facility management as several JUs are located in the same building and share joint business continuity planning, managing office spaces and organising procurements of common infrastructure. Finally, in alignment of the SBA and the future

back office arrangements, the close collaboration among the JUs will be even more enhanced, a joint analysing on possible synergies and cost-efficiencies among JUs will be conducted in 2022 by the different JUs with the support of an external consultant, and will be fully implemented in 2023.

In terms of operational efficiencies, EU-Rail was the first body of the Union together with the Commission to introduce since 2018 the Lump Sum Grant pilot. Nevertheless, during the pilot only part of the activities were implemented in such manner. Based on the experience acquired and in line with the overall targets of Horizon Europe, the lump sum approach will be the implementation way of the Programme. This will provide opportunities to focus the resources on added value functions, in particular on the cost effectiveness of the projects towards achieving the EU-Rail Programme results.

2.4.4.3 Staff establishment plan²¹

The Authorized Budget indicated in the tables below refers to the staffing of the new Europe's Rail JU which started its activities on 30 November 2021; consequently the difference with the actually filled position is due to the fact that it was not possible to recruit the staff and fill the positions by the end of 2021. Recruitments have been launched and all positions are expected to be filled by Q3 2022.

STAFF ESTABLISHMENT PLAN										
Establishment plan posts										
Function group and grade	2021				2022		2023		2024	
	Authorised Budget		Filled as of 31/12/2021		Authorised Budget		Authorised Budget		Authorised Budget	
	Permanent posts	Temporary posts	Permanent posts	Temporary posts	Permanent posts	Temporary posts	Permanent posts	Temporary posts	Permanent posts	Temporary posts
AD 16										
AD 15		1				1		1		1
AD 14				1						
AD 13										
AD 12										
AD 11										
AD 10		2		2		2		2		2
AD 9		1				1		1		1
AD 8		1		1		1		1		1
AD 7				1						
AD 6		4				4		4		4
AD 5		1				1		1		1
AD TOTAL	0	10	0	5	0	10	0	10	0	10
AST 1-11										
AST TOTAL	0	0	0	0	0	0	0	0	0	0
AST/SC 1-6										
AST/SC TOTAL	0	0	0	0	0	0	0	0	0	0
TOTAL		10		5		10		10		10
GRAND TOTAL	10		5		10		10		10	

²¹ 2023 and 2024 staff number are presented based on the Legal Financial Statements annexed to the SBA but are subject to the adoption of the EU General Budget for 2023 and 2024.

Contract agents	FTE corresponding to the authorised budget 2021	Executed FTE as of 31/12/2021	Headcount as of 31/12/2021	FTE corresponding to the authorised budget 2022	FTE corresponding to the authorised budget 2023	FTE corresponding to the authorised budget 2024
Function Group IV	13	13	13	13	15	15
Function Group III	3	3	3	3	1	1
Function Group II	1	1	1	1	1	1
Function Group I						
TOTAL	17	17	17	17	17	17

Seconded National Expert

Seconded National Experts	FTE corresponding to the authorised budget 2021	Executed FTE as of 31/12/2021	Headcount as of 31/12/2021	FTE corresponding to the authorised budget 2022	FTE corresponding to the authorised budget 2023	FTE corresponding to the authorised budget 2024
TOTAL	2	1	1	2	2	2

Recruitment forecasts for 2022 following retirement/mobility or new requested posts					
Job title in the JU	Type of contract (Official, CA, TA)		TA/Official		CA
			Function group/grade of recruitment internal (Brackets) and external (single grade) foreseen for publication		Recruitment Function Group (I, II, III and IV)
	Due to foreseen retirement/mobility	New post requested due to additional tasks	Internal (brackets)	External (brackets)	
	N/A	N/A	N/A	N/A	N/A

2.5 Governance activities

Establishment of the governing, consultation and advisory bodies of the new Europe's Rail Joint Undertaking, and making these bodies operational, is one of the key challenges of 2022.

As follows from the provisions of the SBA, the JU is composed of the following bodies: the Governing Board, the Executive Director, the States' Representatives Group, the System Pillar Steering Group, and the Deployment Group. In addition, EU-Rail may set up a scientific steering group or seek scientific advice from independent academic experts or from shared scientific advisory bodies.

2.5.1 Governing Board

The Governing Board (GB) of EU-Rail was established after the Founding Members of EU-Rail other than the Union signed a letter of commitment detailing the scope of the membership in terms of content, activities and its duration, as well as their contributions to the joint undertaking, including an

indication of the envisaged additional activities referred to in Article 11(1), point (b) SBA.

At the same time of the signature of the letter of commitment they nominated their representatives and alternates to the Board. The first Governing Board meeting was held on 21 December 2021 where the GB adopted its Rules of Procedure²². In the same meeting, the GB adopted the so-called “omnibus decision”²³, i.e. the list of decisions adopted by the S2R JU that will continue to apply for EU-Rail in accordance with Article 174(12) of the SBA.

The GB of EU-Rail is the decision-making body, having the overall responsibility for the strategic orientation, coherence with relevant Union objectives and policies, and operations of the JU. It shall also supervise the implementation of JU’s activities.

The body is composed of two representatives from the Commission on behalf of the Union and one representative from each of the JU’s Founding Members other than the Union.

Representatives of the European Union Agency for Railways (ERA) and of the European Rail Research Advisory Council (ERRAC) shall be invited to attend meetings of the Governing Board as observers and take part in its deliberation, but shall have no voting rights.

The GB shall hold ordinary meetings at least twice a year. Extraordinary meetings may be convened at the request of the chairperson, the Executive Director, the Commission or a majority of the representatives of the members other than the Union or of the participating states. In addition, the GB shall meet once a year in a general assembly and all participants to the research and innovation activities of the EU-Rail shall be invited to attend. The purpose of such assembly would be to stimulate reflection on the overall direction of the JU’s activities, while conducting an open and transparent discussion on the progress of the Master Plan implementation. Such meeting in a general assembly composition is foreseen to be held once the new projects are launched and running.

In 2022, it is foreseen that the EU-Rail’s Governing Board will hold three meetings, on 1 March, 24 June and 30 November. An extraordinary meeting is planned for 3 August in relation to the award of the 2022 call for proposals.

The GB’s key planned activities are listed below:

Key activities in 2022 – timetable	
Adoption of the MP, MAWP, and of the 2022 Work Programme	Q1
Adoption of the 2021 AAR and Final Annual Accounts	Q2
Extraordinary meeting for 2022 Call award	Q3
Adoption of the 2023 Work Programme and general assembly	Q4

2.5.2 Executive Director

The Executive Director is the chief executive responsible for the day-to-day management of the JU in accordance with the decisions of the Governing Board. The Executive Director is the legal representative of EU-Rail. The Executive Director is accountable to the Governing Board. He is supported by the JU staff.

The mandate of the current Executive Director was renewed in 2021 for a period of five years until 15 May 2026.

²² GB Decision n°01/2021

²³ GB Decision n°02/2021

2.5.3 Scientific Steering Group

While the services of a Scientific Committee as an advisory body were utilized for S2R JU, the SBA provides a possibility for EU-Rail to establish a more structured scientific advice. In particular, the JU may set up a scientific steering group or seek scientific advice from independent academic experts or from shared scientific advisory bodies.

In order to ensure that the JU benefits from scientific advice since the beginning of its activities, the Governing Board re-confirmed the S2R Scientific Committee, in adopting the “omnibus decision” on 21 December 2021. During 2022, on a proposal from the Executive Director, the Governing Board will decide on the set-up of scientific advice to be established for EU-Rail for the future years.

2.5.4 States’ Representatives Group

Members States and countries associated to the Horizon Europe framework programme were asked to nominate their representatives to the States’ Representatives Group (SRG).

The SRG shall be consulted, and in particular review information and provide opinions on the matters, such as:

- programme progress of the JU and achievement of its targets and expected impacts as part of Horizon Europe, including the information on calls for proposals and on the proposal evaluation process;
- updating of the Strategic Research and Innovation Agenda in line with the Horizon Europe strategic planning and with other Union and Member States funding instruments;
- links to Horizon Europe and other Union, national and, where relevant, regional initiatives, including cohesion policy funds in line with smart specialisation strategies;
- draft work programmes and annual activity reports;
- involvement of SMEs, start-ups, higher education institutions and research organisations, and measures taken for promoting participation of newcomers;
- actions taken for dissemination and exploitation of results along the value chain.

In addition, the Member States shall ensure that their respective representatives present a coordinated position that reflects their Member State’s views expressed in:

- the committee established by Article 51 of Directive (EU) 2016/797;
- the Programme Committee under Horizon Europe configuration ‘Climate, Energy and Mobility’;
- the Single European Rail Area Committee, established by Article 62 of Directive 2012/34/EU of the European Parliament and of the Council.

One of the key roles of the SRG is to ensure the interface with the JU on integration between the EU-Rail Programme and national, regional and local programmes and initiatives, in relation to R&I as well as dissemination and communications.

Further to the above, the SRG may also issue, on its own initiative, opinions, recommendations or proposals to the Governing Board or the Executive Director on technical, managerial and financial matters as well as on work programmes and other documents, in particular when those matters affect national or regional interests.

For the year 2022, two meetings of the SRG are planned (in Q1 and Q4).

The tentative key activities are listed below:

Key activities in 2022 – timetable	
1st Meeting of the SRG in which it would: <ul style="list-style-type: none"> – Provide advice on the draft 2022 Work Programme; – Provide advice on the results achieved in the previous years and the alignment with the work programme. 	Q1
2nd Meeting of the SRG in which it would: <ul style="list-style-type: none"> – Provide advice on the priorities to be addressed in the 2023 Work Programme, including links with similar research activities carried out for example in HE; – Provide advice to the GB on the programme progress of the EU-Rail's 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; deployment activities in relation to EU-Rail. 	Q4

2.5.5 The System Pillar steering group

The System Pillar steering group (SPSG) shall be an advisory body of the Europe's Rail Joint Undertaking in charge of providing advice on System Pillar issues.

It is foreseen that the SPSG shall be composed of representatives of the Commission, representatives of the rail and mobility sector and of relevant organisations, the EU-Rail's Executive Director, the chairperson of the SRG and representatives of the ERA and of the ERRAC. The body should be chaired by the Commission.

It will be the task of the SPSG to provide advice to the Executive Director and Governing Board on matters, such as the following:

- the approach to operational harmonisation and the development of system architecture, including on the relevant part of the Master Plan;
- delivering on the specific objective regarding introducing a unified operational concept and a functional, safe and secure system architecture; as well as an integrated European rail traffic management, command, control and signalling systems, including automated train operation;
- carrying out the task related to developing within the System Pillar a system view that reflects the needs of the rail manufacturing industry, the rail operating community, Member States and other rail private and public stakeholders, including bodies representing customers, such as passengers and freight and staff, as well as relevant actors outside the traditional rail sector;
- monitoring the progress of the System Pillar.

It is expected that the activities of the System Pillar Group will start formally in Q2 2022.

2.5.6 The Deployment Group

The role of the Deployment Group shall be to advise the Governing Board on the market uptake of rail innovation developed under EU-Rail. It shall provide recommendations on issues related to the deployment of rail innovative solutions, either upon request of the Governing Board, or on its own initiative.

The Deployment Group should consist of European rail representatives, in particular of Infrastructure Managers and Rail Operators, but also of suppliers, to ensure the preparedness of products and to advise the JU on how a coordinated and integrated deployment can be organised. The composition of this group may be variable, considering the scope of its activities.

More specifically, the Deployment Group should:

- Examine and provide recommendations on alternative scenarios for the rollout of innovative solutions;
- Prepare a roadmap for the coordinated and integrated deployment of the relevant rail research and innovation results, where relevant in cooperation with other modes of transport;
- Examine the human factor elements and the behavioural and organisational changes resulting from deployment;
- Ensure consideration of diversity of situations across the Union, including most cost-effective possibilities of retrofitting from a medium and long-term perspective;
- Contribute to the alignment of deployment and investment plans also including other modes of transport and other relevant infrastructures;
- Assess the risks and opportunities associated to uncoordinated initiatives;
- Contribute to phasing out of existing legacy systems and consideration on the necessary accompanying funding and financial measures, from public and private sources, including EIB;
- Suggest a performance scheme that would contribute to accelerating deployment and/or any other relevant measures;
- Examine any other relevant matter that would contribute to shortening of the innovation lifecycle and increasing the performance of rail, while maintaining the same or even higher level of its safety.

It is expected that the activities of the Deployment Group will start formally in Q3 2022.

2.6 Strategy and plans for the organisational management and internal control systems

2.6.1 EU-Rail organization

EU-Rail is organized in three Units and some functions reporting directly to the Executive Director.

The Programme is within the remit of the Head of the Programme, who reports to the Executive Director, and has direct responsibility for the Innovation Pillar Unit and ensure the coordination with the System Pillar Unit. The Head of the Corporate Services Unit, reports to the Executive Director, and he is responsible to provide the necessary financial, administrative and compliance support in relation to the activities of the JU. The Internal Control Coordinator, the HR Officer and the Stakeholder relations and Dissemination reports to directly to the Executive Director.

The organization has established its way of working, “EU-Rail ingredients”, which contains a series of elements to define the commitment of the staff to strive to a values’based organization.

2.6.2 Internal Control Framework

In 2019, the JU started the process of implementing the new Internal Control Framework (ICF) based on the EC internal control standards, also with the objective of introducing a more pro-active approach in the design and implementation of internal controls, rather than focusing mostly on the compliance

aspects. This process resulted in 2020 in the adoption of a revised ICF by means of the Executive Director's Decision ED-20-08.

The EU-Rail's ICF is designed to provide reasonable assurance regarding the achievement of the following objectives:

- Effectiveness, efficiency and economy of operations;
- Reliability of reporting;
- Safeguarding of assets and information;
- Prevention, detection, correction and follow-up of fraud and irregularities;
- Adequate management of the risks relating to the legality and regularity of the underlying transactions, taking into account the multiannual character of programmes as well as the nature of the payments concerned.

The achievement of these ICF objectives are built, besides other elements, on:

- procedures for selecting the best projects through independent evaluation, and for translating them into legal instruments;
- project and contract management throughout the lifetime of every project;
- ex-ante checks of claims, including receipt of audit certificates and ex-ante certification of cost methodologies;
- ex-post audits on a sample of claims as part of the Horizon 2020/Horizon Europe ex-post audit strategy;
- scientific evaluation of project results.

Furthermore, the adherence to ethical and organisational values will continue to be one of the key roles of the Joint Undertaking, subject to monitoring by the Commission. The Executive Director, as the Authorising Officer, will promote a cost-effective system of internal control and management and will be required to report to the GB in this respect. The GB will monitor the risk of non-compliance through the reporting system that it will develop, as well as by following the results of ex-post audits on the recipients of EU funds from EU-Rail, as part of the ex-post audit strategy covering the whole of the Horizon 2020 and Horizon Europe framework programmes. In the application of its control system, the JU will strive for striking a balance between attaining an acceptable error rate on one hand, and a reasonable control burden on the other hand. In other words, the need to manage the budget in an efficient and effective manner and to prevent fraud will be combined with the view of avoiding of the Union's Research programme becoming less attractive for the stakeholders from the industry.

In Q1 2022, an annual assessment of the EU-Rail's ICF will be conducted both at the level of its individual 17 principles, and from the perspective of the framework as a whole. The assessment will also take into account possible recommendations resulting from audits performed by the Internal Audit Service of the Commission and of the European Court of Auditors, as applicable. Its results will be presented in the 2021 Annual Activity Report.

The most relevant JU's control components are further described in the following sections.

2.6.3 Financial procedures

EU-Rail shall fully comply with the requirements of Regulation (EU, Euratom) 2018/1046 (the Financial Regulation). In compliance with its Article 71, the Joint Undertaking will respect the principle of sound financial management. EU-Rail shall also comply with the provisions of the Model Financial Regulation applicable to the Joint Undertaking. Any departure from this Model Financial Regulation, required for the purpose of the Joint Undertaking's specific needs, shall be subject to the Commission's prior consent. Monitoring arrangements, including through the Union representation in the Governing

Board, as well as reporting arrangements, will ensure that EU-Rail can meet the accountability requirements both to the College and to the Budgetary Authority.

With regard to ICT tools applied to support its financial procedures, since 2016, the JU has utilized ABAC Workflow. At the time of deployment of this tool, the JU adopted its Manual of Financial Procedures including the applicable Financial Circuits. This Manual of Financial Procedures was further revised in a new version in 2017, and amended again later in 2019.

The Manual of Financial Procedures has been designed to guarantee a segregation of duties and to apply the four eyes principle in JU's financial transactions. It describes in detail the financial circuits the EU-Rail 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 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. The impact of the Internal Control Framework adopted in 2020 on the JU's financial procedures continues to be assessed, and further adjustments may be introduced, also taking into account experience gained with the implementation of these processes and procedures.

To be noted that the JU has started the revision of the main documents underpinning its activities to adapt them to the new framework and programme.

2.6.4 Ex-ante and ex-post controls

With the new Programme under Horizon Europe only launching in 2022, the focus of ex-ante and ex-post controls will remain with the ongoing projects governed by the Horizon 2020 rules. For these projects, EU-Rail will continue to follow the procedures for ex-ante and ex-post controls established in its Financial Rules as well as guidelines applicable to Horizon 2020.

EU-Rail follows *the Article 21(1)* of its Financial Rules providing that "each operation shall be subject at least to an ex-ante control relating to the operational and financial aspects of the operation, on the basis of a multiannual control strategy which takes risk into account". 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 JU's projects and other). In addition to the processes defined internally, EU-Rail is implementing the Horizon 2020 ex-ante control framework for its grants.

In accordance with *Article 22* of the EU-Rail Financial Rules, ex-post controls are defined as the controls executed to verify financial and operational aspects of finalised budgetary transactions. 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 ex-post controls of EU-Rail's 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 July 2021, CAS confirmed the selection for the 2022 local representative audit targets for the JU. EU-Rail will report the outcome of the ex-post audits performed in 2021 on the specific sample on its validated cost claims. This reporting will include the error rates identified and applicable to the JUs population.

In addition, the 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 2022, the ex-post review on administrative expenditure will continue to be organised as an annual exercise.

2.6.5 Audits

In accordance with *Article 28* of the EU-Rail Financial Rules, the internal audit function shall be performed by the Commission's Internal Audit Service (IAS).

The internal auditor shall advise EU-Rail on dealing with risks, by issuing independent opinions on the quality of management and control systems, and by issuing recommendations for improving the implementation of operations and promoting sound financial management. Following a risk assessment performed at the JU during 2020, the Internal Auditor drew up the Strategic Internal Audit Plan for 2021-2023 which will be the basis for the internal audit work to be carried out as of 2021. In Q4 2021 the JU provided IAS with an update on the internal and external developments having influence on its business, as well as with its updated version of the risk register. IAS will take this input into account for the preparation of its planning of the audit work for 2022 and for the establishment of the next in-depth risk-assessment and strategic internal audit plan of EU-Rail.

The currently ongoing *Audit on H2020 grant implementation and closing* conducted by IAS is expected to be finalized in 2022. EU-Rail will take into account the recommendations that may result from this audit in the design of its control framework and control practices by means of an appropriate action plan.

The financial audit of the JU's 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 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 their findings.

In its annual report on EU Joint Undertakings for the financial year 2020, no major issue was reported by the ECA for the S2R JU.

Two observations were raised for follow-up regarding:

- The requirement that up-to-date CVs and conflict of interest declarations of the JU's GB members are published on the JU's website;
- Incorrect method applied by two beneficiaries for the calculation of declared personnel costs and control weakness related to the absence of the beneficiary's validation procedure for the hours declared as worked on the project.

The JU has duly taken note of the observations raised by the ECA and will therefore thoroughly follow-up on these two findings in 2022.

Regarding the ex-post audits on grants, the 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.

2.6.6 Risk Management

EU-Rail has an established Risk Management that has been implemented within the JU for the last 5 years. It is a continuous process involving clear communication to governance, staff and stakeholders on how EU-Rail positions itself in the management of risks and opportunities that can affect the achievement of its objectives, taking into consideration the assessment of the level of uncertainty that the JU is willing to accept (risk appetite). The Executive Director approves the policy and sets the tone, staff at the different levels implement the policy in the day-to-day operations. The Governing Board endorses the JU's risk register brought to its attention by means of the Annual Activity Report.

In the months of September and October 2021, in accordance with the JU's Policy for Risk Management as defined in its Governance and Process Handbook, the JU performed a risk assessment exercise with the aim of updating the elements related to risks and opportunities already included in its risk register, as well as identifying potential new ones. Within this exercise, the specificities of the transition period from S2R JU to EU-Rail were also duly taken into account, similarly to other topical internal and external factors and developments having influence on JU's business. Due attention was given also to the fraud risks.

The management of risks during 2022 will be based on the results of the above mentioned risk assessment exercise carried out during 2021 (see also Section 2.3.1, the part titled "Other risks"), revised taking into consideration the most recent developments. In the course of 2022, it is foreseen to run an in-depth risk assessment to identify both operational and non-operational (corporate) risks that may affect the achievement of the JU's objectives.

2.6.7 Anti-fraud strategy

EU-Rail has an formalized anti-fraud strategy that was established in 2017. It is based on three main objectives, in particular:

- to maintain a culture of integrity among staff and to build capacities through training and guidance;
- to ensure a high level of reactivity in case a fraud case is suspected, with the involvement of OLAF;
- to prevent leakage of sensitive/confidential information, and thus, to prevent a misuse of such unauthorised access to that information.

Integral part of the anti-fraud strategy is its action plan providing particular activities and measures carried out in order to mitigate the risk of fraud. The actions included in this action plan aim at covering all stages of the anti-fraud cycle: prevention, detection, investigation and corrective measures. The action plan is updated and the individual actions are followed up and assessed on a bi-annual basis. In performing these activities, EU-Rail takes advantage of knowledge and experience gained by participating in the Fraud and Irregularities in Research Committee (FAIR) and its substructures.

Since the JU considers conflict of interest a potential prerequisite for possible fraudulent behaviour, various established measures will continue to be applied at EU-Rail to mitigate this inherent risk, such as:

- declarations on non-existence of conflict of interest by the staff members;
- utilization of independent experts in selection procedures who will be obliged to declare any potentially conflicting interests;
- annual declaration of interests by the Governing Board members, as well as declaration of confidentiality and conflict of interest by all attendees to each EU-Rail's Governing Board meeting.

Given the specificities related to the transition from the S2R JU to EU-Rail, the current anti-fraud strategy was extended until 30 June 2022. In 2022, a new EU-Rail's anti-fraud strategy is foreseen to be drafted and adopted, taking also on board the newest available elements and requirements

provided in the relevant anti-fraud-related documents of the Commission, Research Family and DG MOVE, and also following up on the developments related to the common joint undertaking back office, as foreseen by Article 13 of the SBA.

In parallel to the separate attention paid to fraud risks and their mitigation via a dedicated anti-fraud strategy, due attention was given to the risks of fraud, both internal and external, also within the latest risk assessment exercise performed in the months of September and October 2021. These risks are included in the JU's overall risk register and will be subject to regular reassessment in 2022.

3. BUDGET 2022-2024 ²⁴²⁵

In accordance with Article 4 of the Commission Decision on the Horizon Europe's work programme for 2021-2022, the cumulated changes to the allocations to specific actions not exceeding 20% of the maximum Union contribution set in this Work Programme shall not be considered to be substantial for the purposes of Article 110(5) of the Financial Regulation, where those changes do not significantly affect the nature of the actions and the objective of the ad hoc financing decision. The EU-Rail responsible authorising officer may apply the changes referred to in this Commission Decision. Those changes shall be applied in accordance with the principles of sound financial management and proportionality.

²⁴ 2023 and 2024 Budget (Commitment and Payment appropriations) are subject to the adoption of the EU General Budget for 2023 and 2024. All figures may be updated during both of these adoption procedures.

²⁵ The EFTA rate used for 2024 is the one known and applicable for the year 2022. This could be subject to revision when the EFTA rate 2024 will be available.

STATEMENT OF REVENUE											
Title Chapter	Heading	Financial Year 2022				Financial Year 2023			Financial Year 2024		
		Estimate Commitment Appropriations	In %	Estimate Payment Appropriations	In %	Estimate Commitment Appropriations	Estimate Payment Appropriations	In %	Estimate Commitment Appropriations	Estimate Payment Appropriations	In %
EU contribution (excluding EFTA and third countries contribution)[2]		163.590.298	96%	154.140.257	85%	91.734.166	83.767.282	88%	104.420.806	71.768.434	86%
of which (fresh C1) Administrative (Title 1&2)		3.463.928	2%	4.669.633	3%	2.346.053	3.578.711	4%	2.405.582	2.933.653	4%
of which frontloaded commitments (Title 1 and Title 2)		-		-		-	-		-	-	
of which Operational (Title 3)		160.126.370	94%	149.470.624	83%	89.388.114	80.188.571	84%	102.015.224	68.834.781	83%
Of which related to additional entrusted tasks											
EFTA and third countries contribution		2.237.580	1%	3.328.732	2%	2.265.834	2.027.468	2%	2.579.194	1.770.779	2%
of which Administrative EFTA(Title 1&2)		56.709	0%	82.150	0%	57.947	83.957	0%	59.418	70.560	0%
Of which administrative third countries excluding EFTA (Title 1&2)											
of which Operational EFTA (Title 3)		2.180.871	1%	3.246.582	2%	2.207.886	1.943.512	2%	2.519.776	1.700.219	2%
Of which operational third countries excluding EFTA (Title 3)											
Financial Members other than the Union contribution		4.751.783	3%	4.751.783	3%	3.662.668	3.662.668	4%	3.004.213	3.004.213	4%
of which Administrative (Title 1&2)		4.751.783	3%	4.751.783	3%	3.662.668	3.662.668	4%	3.004.213	3.004.213	4%
of which Operational (Title 3)											
Financial Contributing partners contribution											
Interest generated											
Unused appropriations from previous years		-	0%	18.126.076	10%	3.295.420	5.648.867,57	6%	4.505.547	6.545.996	8%
Of which administrative		-	0%	626.076	0%	3.295.420	5.152.641,42	5%	4.505.547	5.121.120	6%
Of which operational		-	0%	17.500.000	10%	-	496.226,15	1%	-	1.424.876	2%
TOTAL ESTIMATE REVENUE		170.579.661	100%	180.346.848	100%	100.958.087	95.106.285	100%	114.509.761	83.089.422	100%

STATEMENT OF EXPENDITURE													
Title Chapter	Heading	Financial Year 2022				Financial Year 2023				Financial Year 2024			
		Estimate Commitment Appropriations	% Ratio	Estimate Payment Appropriations	% Ratio	Estimate Commitment Appropriations	% Ratio	Estimate Payment Appropriations	% Ratio	Estimate Commitment Appropriations	% Ratio	Estimate Payment Appropriations	% Ratio
			[Year N/year N- 1]		[Year N/year N- 1]		[Year N+1/year N]		[Year N+1/year N]		[Year N+1/year N]		[Year N+1/year N]
1- Staff													
Salaries & allowances													
- Of which establishment plan posts	110	1.638.000,38	1%	1.638.000,38	1%	1.670.760,00	102%	1.670.760,00	102%	1.703.520,00	102%	1.703.520,00	102%
- Of which external personnel	111	1.480.000,00	1%	1.480.000,00	1%	1.509.600,00	102%	1.509.600,00	102%	1.539.200,00	102%	1.539.200,00	102%
Expenditure relating to Staff recruitment													
Mission expenses	130	150.000,00	0%	150.000,00	0%	153.000,00	102%	153.000,00	102%	156.060,00	102%	156.060,00	102%
Socio-medical infrastructure													
Training	150	50.000,00	0%	50.000,00	0%	51.000,00	102%	51.000,00	102%	52.020,00	102%	52.020,00	102%
External Services													
Receptions, events and representation													
Social welfare													
Other Staff related expenditure	190	314.000,00	0%	314.000,00	0%	320.280,00	102%	320.280,00	102%	326.685,60	102%	326.685,60	102%
2-Infrastructure and operating													
Rental of buildings and associated costs	200	345.000,00	0%	345.000,00	0%	351.900,00	102%	351.900,00	102%	358.938,00	102%	358.938,00	102%
Information, communication technology and data processing	210	150.000,00	0%	150.000,00	0%	150.000,00	100%	150.000,00	100%	150.000,00	100%	150.000,00	100%
Movable property and associated costs	220	10.000,00	0%	10.000,00	0%	10.000,00	100%	10.000,00	100%	10.000,00	100%	10.000,00	100%
Current administrative expenditure	230	15.000,00	0%	15.000,00	0%	15.000,00	100%	15.000,00	100%	15.000,00	100%	15.000,00	100%
Postage / Telecommunications	240	15.000,00	0%	15.000,00	0%	15.000,00	100%	15.000,00	100%	15.000,00	100%	15.000,00	100%
Meeting expenses	250	50.000,00	0%	50.000,00	0%	50.000,00	100%	50.000,00	100%	50.000,00	100%	50.000,00	100%
Running costs in connection with operational activities	260	50.000,00	0%	50.000,00	0%	100.000,00	200%	100.000,00	200%	50.000,00	50%	50.000,00	50%
Information and publishing	270	550.000,00	0%	550.000,00	0%	300.000,00	55%	300.000,00	55%	550.000,00	183%	550.000,00	183%
Studies													
Other infrastructure and operating expenditure	290	160.000,00	0%	160.000,00	0%	160.000,00	100%	160.000,00	100%	160.000,00	100%	160.000,00	100%
TOTAL ADMINISTRATIVE (1+2)		4.977.000,38	3%	4.977.000,38	3%	4.856.540,00	98%	4.856.540,00	98%	5.136.423,60	106%	5.136.423,60	106%
3-Operational													
TOTAL OPERATIONAL (3)		162.307.240,94	95%	169.720.979,59	94%	91.596.000,00	56%	85.128.624,81	50%	104.535.000,00	114%	72.499.088,81	85%
Unused Appropriations													
TOTAL Unused		3.295.419,84	2%	5.648.867,57	3%	4.505.547,40	137%	5.121.120,09	91%	4.838.337,00	107%	5.453.909,69	106%
ESTIMATE TOTAL EXPENDITURE		170.579.661,16	100%	180.346.847,54	100%	100.958.087,40	59%	95.106.284,89	53%	114.509.760,60	113%	83.089.422,10	87%

Table of Financial programming per year until 2027 (incl annual instalments)

	2022	2023	2024	Total	Ratio vs maximum Union contribution (art10 SBA) - max 50%	Total 2022-2024
<i>Total amount to be assigned via annual instalments (Calls)</i>	234.000,0					
<i>Amount of annual instalments</i>	135.707,2	73.496,0	24.796,8	234.000,0	40,6%	
<i>Amount to be assigned on annual budget (other calls/tenders/experts)</i>	26.600,0	18.100,0	18.100,0	62.800,0		
<i>Available Commitment appropriations</i>			61.638,2			
<i>Total annual budget (operational EU-Rail Programme)</i>	162.307,2	91.596,0	104.535,0			358.438,2
	2025	2026	2027	Total	Ratio cumulative budget of the residual years (min 20%)	Gran total 2022-2027
<i>Total amount to be assigned via annual instalments (Calls)</i>	141.750,0					
<i>Available Commitment appropriations</i>	61.638,2					
<i>Amount of annual instalments</i>	73.363,0	6.748,8		80.111,8		
<i>Amount to be assigned on annual budget (other calls/tenders/experts)</i>	18.100,0	70.627,2	48.722,8	137.450,0	63,2%	
<i>Total annual budget (operational EU-Rail Programme)</i>	91.463,0	77.376,0	48.722,8			576.000,0

4. ANNEXES

Annex I - IKAA plan

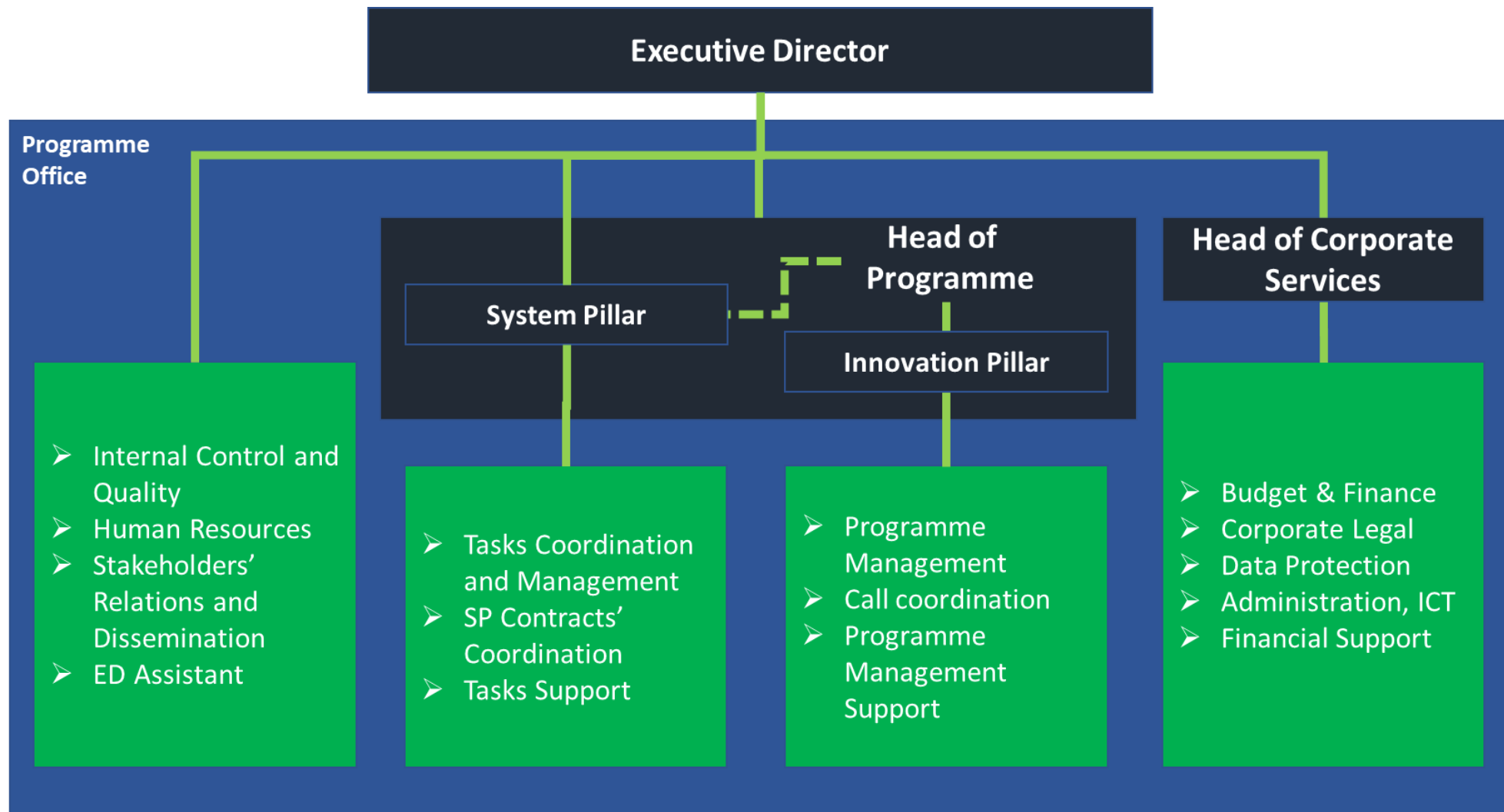
The IKAA plan will be provided following the outcome of the first Call 2022 as the additional activities proposed by the Founding Members in their letter of commitment are related to the future EU-Rail Projects.

The Executive Director will submit an amended Work Programme to update the IKAA plan following the award decision of the Governing Board on the first Call 2022.

OVERVIEW ESTIMATED AMOUNT OF IKAA FOR [YEAR N]					
Additional Activities type	Description of the Additional Activities	Country of establishment of the contributor	Link to JU objectives / KPIs	Link to JU project/ topic (if relevant)	Estimated annual value (in M€)
1. Support to additional R&I					
2. Scale up of technologies					
3. Demonstrators					
4. Creating new business opportunities					
5. Training & skills development					
6. Contribution to the development of new standards, regulations and policies					
7. Supporting ecosystem development					
8. Communication, dissemination, awareness raising, citizen engagement					
9. Others					
TOTAL ALL PLANNED IKAA					
IKAA BREAKDOWN PER COUNTRY					
Country	Estimated value				

Additional Activities can be accounted for as Private Members' In-Kind Contributions for Additional Activities, when they contribute to the objectives of EU-Rail and are directly linked to its activities, including non-eligible costs of indirect actions funded by EU-Rail, where this is provided for in the present annual additional activities' plan. Subject to the compliance with the aforementioned definition, the adoption of the present annual additional activities' plan and the signature of the respective grants, Additional Activities shall be considered eligible as In-Kind Contributions from the start date of the action, including in the case of early start date, and up to two years following the end of the action.

Annex II - Organisational Structure of the Programme Office of EU-Rail



Annex III – Key Performance Indicators for Europe’s Rail Joint Undertaking

TABLE I - Horizon Europe Key Performance Indicators common to all JTI JUs

NOT YET PROVIDED BY DG RTD

TABLE II - Indicators for monitoring Horizon Europe Cross-Cutting Issues common to all JTI JUs

NOT YET PROVIDED BY DG RTD





TABLE III - Key Performance Indicators specific for EU-Rail




A number of Key Performance Indicators (KPIs) have been identified in the Multi-Annual Work Programme for each Flagship Area. Each JU project will produce consistent quantitative and qualitative metrics during its implementation, so as to determine the actual R&I progress and results achieved.

Starting from this comprehensive list of KPIs that will constitute the basis for the Layer 1, a selection of the most relevant ones by Impact areas is presented in the table below. It is to be noted that further consolidation of KPIs, accompanied by modelling of the rail system/sub-systems impacts, will be performed in the course of the Programme.

This selection, using as a reference baseline the state of the art in 2020 (including results from S2R), will allow a more focused transformation of the operational work delivered with Projects technical and operational results into more tangible Societal Impact qualifications.

The Societal Impact measurement methodology will be developed in the first two years of the functioning of the Joint Undertaking on the basis the technical and operational KPIs provided here. The calculations of the impact will be provided after each round of demonstrators that is in 2025, 2027 and 2031.

Impact areas	Key performance indicators	Rationale	Driver Targets ¹
1. Customer requirements 	Accuracy in total planned travel time of passengers from improved matching between supply and demand, #	Increase availability and predictability of intermodal rail transport offer	75%
	Traffic planning certainty, #	Planning certainty, considering the demand forecast, is a key requirement for planning on time, reliable and efficient service delivery	between 65% and 80% ¹
	Handling/response time for intermodal freight offers and regional passenger services, mins	Improve overall customer experience, including growing intermodal freight transport and regional passenger services	-50%
2. Improved Capacity 	Trains on line per hour and direction, #	Increased frequency is a key element for improved capacity	At least +10% ²
	Reduction of total freight transport time, mins	Reduced freight transport time leading to better asset utilization and increased capacity	-33%
	Increased average freight train length in existing infrastructure limitations or higher loads, meters	Increased length directly leads to more available capacity	Up to 1.500m
3. Reduced Costs 	Overall OPEX and CAPEX costs of regional lines, incl. maintenance, infrastructure and vehicles	Direct link to lower costs of the regional lines	tbc ³
	Maintenance costs, including thanks to the use of digital twins, €	Direct link to lower costs	-10% ⁴
	Design and manufacturing costs, €	Leading to reduced investment cost	-20%
	Virtual certification tasks that can be conducted in a laboratory, #	Cost of virtual certification activities is much lower than cost of physical certification activities, hence more tasks done virtually leads to lower costs	+80% ⁵
4. Sustainable and resilient transport 	Optimized energy consumption and higher punctuality in regional services, kWh per pax-km or tons-km;mins	More efficient operations, leading to lower energy consumption (with lower CO2 emissions)	-10% (energy); +15% (punctuality)
	CO ₂ equivalent emissions	Further decrease rail carbon intensity	Up to 30% for specific use cases (e.g. regional operation and heavy duty inspection vehicles)
	Traffic prediction performance, secs	Improve network resilience through dynamic infrastructure restriction handling, train regulation and automated conflict resolution	<120 secs ⁶
	Time to respond and resolve a vulnerability (regarding cyber security), mins	Reduced impact of events and increased availability of the rail system	tbc ⁷

Impact areas	Key performance indicators	Rationale	Driver Targets ¹
5. Harmonized approach 	CCS system CAPEX and OPEX (of main line and regional lines systems), while maintaining or increasing the present safety level	Reducing costs associated with the interoperability of the network will enhance harmonization	CAPEX: -25% (regional lines) and -10% (main lines); OPEX -20% (regional and main lines)
	No new national technical rules triggered by innovative solutions coming from the Joint Undertaking and potential reduction of national rules in relation to ERTMS and interlocking	By decreasing the amount of national rules in force, rail transport will evolve towards the Single European Railway Area	N/A
	Reduction of answering time between the short term request of a cross-border train path and the answer with a firm offer, <i>mins</i>	Indicator for more efficient border crossing	down to 5 mins
	Operational dwell time at borders and other handover points relying also on relying on more homogenous system approaches (leading to increase number of trains on given infrastructure), <i>mins</i>	Indicator for more efficient border crossing	-50%
6. Reinforced role for rail 	Accuracy in total planned travel time of passengers from improved matching between supply and demand, %	The combination of the indicators from Impact Areas 1 and 3 contribute to more effective and cost-efficient rail transport, thereby improving attractiveness of rail compared with other transport modes	75%
	Traffic planning certainty, #		between 65% and 80% ¹
	Handling/response time for intermodal freight offers and regional passenger services, <i>mins</i>		-50%
	Overall OPEX and CAPEX costs of regional lines, incl. maintenance, infrastructure and vehicles		Tbc3
	Maintenance costs, including thanks to the use of digital twins, €		-10% ⁴
	Design and manufacturing costs, €		-20%
	Virtual certification tasks that can be conducted in a laboratory, #		+80% ⁵
7. Improved 	Maturity of innovative technologies	Innovative technologies will deploy rail capabilities and leverage potential competitive advantages for the EU rail industry	TRL 8

¹ Depending on point in time, e.g. one week in advance or one hour in advance

² At the moment this KPIs is linked with the outcome of FA2 only, in the course of the programme a consolidated KPI will be measured

³ The nature of the activity requires a full system approach analysis from improvements at components level, which will be conducted during the course of the programme

⁴ In specific use cases for both rolling stock and infrastructure and asset management

⁵ Costs only related to the execution of the on-site tests

⁶ In a typical scenario of at least 100 trains running in a 2h interval ahead of actual time

⁷ Due to the confidentiality nature of the baseline, a KPI measure will be assessed and consolidated during the course of the programme

⁸ As reflected in the ERA database(s) in relation to OPE TSI Appendix A, annex C and other TSIs in relation to ERTMS and interlocking

Annex IV – KPIs and TRLs for Shift2Rail Programme

TABLE I – Initial estimation of Release 4.0 - of the Key Performance Indicators of the Shift2Rail Programme

To be updated at the GB meeting, following the KPI presentation of Release 4

SPD	LCC	Capacity	Punctuality
Target	-50%	+100%	+50%
High Speed	-19% <small>-20%</small> <small>-15%</small> <small>-18%</small>	62% <small>62%</small> <small>69%</small> <small>74%</small>	35% <small>35%</small> <small>29%</small> <small>19%</small>
Regional	-36% <small>-37%</small> <small>-21%</small> <small>-24%</small>	74% <small>74%</small> <small>57%</small> <small>49%</small>	53% <small>53%</small> <small>51%</small> <small>15%</small>
Metro	-18% <small>-18%</small> <small>-16%</small> <small>-18%</small>	25% <small>25%</small> <small>23%</small> <small>28%</small>	n/a <small>n/a</small> <small>n/a</small> <small>19%</small>
Freight	-39% <small>-39%</small> <small>-39%</small> <small>-40%</small>	94% <small>94%</small> <small>42-114%</small> <small>91%</small>	57% <small>57%</small> <small>78%</small> <small>71%</small>

release 3.2

release 2.0

release 1.0

TABLE II – Overview of demonstrators for S2R JU projects with a Technology Readiness Level reaching at least value 6

IP	Research Area	Specific Technological demonstration of	characteristics					Overall high level focus/objective
			Market	Testing time - YEAR start	Testing time - YEAR end	Country	TRL	
IP1	TD1.1 Traction	New Technology Traction Systems	Metro	2022	2022	ES	6/7	New generation traction converter based on advanced semiconductor technologies : Reduction in weight and size and increase in energy efficiency
			Regional	2021	2022	FR	6/7	SiC based powertrain demo on a Regional Train
		New Traction Architectures	High Speed	2021	2022	ES	6/7	Traction motor and traction drive architecture
	TD1.2 Train Control & Monit. System (TCMS)	Wireless TCMS	Metro	2022	2023	ES	6/7	Incorporate wireless technologies to the train communication network solutions (i.e. train backbone, consist network and train to ground communication).
			Regional	2022	2023	DE	6	
		Drive-by-data	Metro	2022	2023	ES	6/7	Provide a train-wide communication network for full TCMS support including the replacement of train lines, connecting safety functions up to SIL4 (incl. signalling).
			Regional	2022	2023	DE	6	
		Functional distribution architecture	Metro	2022	2023	ES	6/7	New architectural concept based on standard framework & application profiles, distributed computing to allow execution of compliant functions on end devices distributed meeting different safety & integrity requirements
			Regional	2022	2023	DE	6	
	TD1.3 Carbody Shell	New materials in train carbody structures	High Speed	2022	2023	ES	6	Full high speed intermediate coach interfacing with the adjacent coaches and the running gear, together with the internal interfaces of the main representative equipment of the train (HVAC, etc.) and integrated in a high speed train
	TD1.4 Running Gear	Sensing functionality	Urban/Suburban	2022	2023	ES	6/7	New health monitoring systems that allows a condition based maintenance of the track with Novel sensor system (hardware), Wireless communication of some sensor, Innovative algorithms
			Regional	2022	2023	HU	6/7	Wireless on-board, in-service monitoring system with access to external information that provides the required data for a condition-based maintenance.
		Optimised Materials	Regional	2022	2022	FR	6/7	Composite Antenna Beam: Design of an Antenna Beam out of composite material to reduce weight
		Bogie Control	Generic	2022	2022	AT/DE	6/7	Active wheelset guidance system for reduction of wheelwear and therefore maintenance cost
	TD1.5 Brakes	SIL 3/4 electronic solutions for Brake Control	Urban/Regional	2021	2022	ES	7	Train braking system, based on new architectural HSIL concept, including the replacement of conventional train lines(tbc) and connecting braking safety functions up to SIL4.
		Innovative Friction Pair Solutions		2021	2022	ES	7	High power and eco-friendly friction pairing solution to be tested in a relevant environment
		Adhesion Management	Generic	2021	2022	ES	6	Function of a new adhesion management concept/ function within an relevant environment on a test train
		Electro Mechanic Brake		2022	2023	HU or DE	6	Mechatronic brake actuator
	TD1.6 Door and Intelligent Access system	PRM access and communicating door	Regional	2022	2023	FR, ES	7	New door functionalities like platform detection, passenger detection, passenger protection during boarding aid deployment and retract...
		Light and high comfort door	Regional	2022	2023	FR and/or ES	6	Opening and closing mechanism and the leaves new innovative design: - one door will be based on metallic solutions - another door will be based on composite solutions
	TD1.7 Interiors	New Passengers Interiors	Regional	2022	2023	ES	6	Modular interiors: physical mock-up of a partition and two virtual mock-ups of global concepts
	TD1.8 HVAC	HVAC-Technology with natural gases	Regional	2020	2022	DE	7	Test in real operation on regional trains, suggestion for Standardisation of interfaces, reduction of climatic impact and energy consumption

IP	Research Area	Specific Technological demonstration of	characteristics					Overall high level focus/objective
			Market	Testing time - YEAR start	Testing time - YEAR end	Country	TRL	
IP2	TD2.1 Advanced Communication System	markets applications	Mainline/High Speed	2021	2023	FR/DE	6/7	The demonstrators will be used to validate aspects and capabilities defined in the ACS specification documents (incl. support VoIP communication) and assess them in the context of related FRMCS specifications.
		markets applications	Urban/Suburban	2021	2023	UK	6/7	
		markets applications	Regional/Freight	2021	2023	IT	6/7	
	TD2.2 Automatic Train Operation	Demonstrate the feasibility of GoA3/4 solution on actual pilot train and line	Urban/High Speed/Regional/Freight	2022	2023	DE, IT, NL	6/7	For GoA3/4, to check the behaviour of the system (ATO on board and ATO trackside) in a real pilot line.
	TD2.3 Moving Block	Higher Capacity	Urban/Suburban	2021	2023	UK	6/7	Moving Block Demonstration for Urban / Suburban, High Speed and Low traffic railway, aiming to show capacity increase on existing infrastructure, compared with traditional signalling, in lab environment
		Higher Capacity	High Speed Railways	2021	2023	DE, FR	6/7	
		Lower Cost	Low Traffic Railway	2021	2023	SE, IT	6/7	
	TD2.4 Safe Train Positioning	functional block integrated into an ERTMS based solution	Regional/Freight	2021	2022	IT	6	Under review for successful Fail Safe Train positioning demonstration innovative solution integrated with an ERTMS based system
	2.5 On-board Train Integrity	On-Board Train Integrity	Low density traffic lines	2022	2022	CZ	6/7	On-Board Train Integrity, wired on-board communication
		On-Board Train Integrity	Freight	2022	2022	UK	6/7	On-Board Train Integrity, wireless on-board communication and energy harvesting
		On-Board Train Integrity	Regional	2022	2022	IT	6/7	On-Board Train Integrity, wired on-board communication, ETCS backward compatibility.
	TD2.6 Zero on-site testing	Simulation and testing environment able to support automated laboratory testing	Mainline/Regional/Freight	2021	2023	N/A	6	Corridor 1 of ETCS System could be used for verification of the testing activities with distributed test environments connected to each other from different trackside and on-board suppliers + Human Factors testing
	TD2.9 Traffic management system	Connected Driver Advisory System	Generic	2021	2022	IT	6	Prototype that implements the computation of speed profile and driving modalities to feed a Connected Driver Advisory System (C-DAS)
		Conflict Prediction System		2022	2023	CZ	6	Prototype demonstrating complex Conflict Prediction System.
		Wayside ATO constituents		2022	2023	SE, PL	6	Constituents needed for ATO GOA2 operation based on data management based on the integration Layer.
		Conflict Detection and Resolution		2020	2022	DE	6	Business service applications for the detection of future conflicts, the presentation of the results to the operator and conflict resolution measures and integration into workflow.
		Application Modules		2020	2022	DE	6	Interaction between the TMS providing indication of asset failure on the Integration Layer + selected features of Operator workstation with 3rd party application HMI
	TD2.10 Smart radio-connected all-in-all wayside objects	Verification of Wireless Low Power Object Controller	Generic	2021	2022	ES	6	Autonomous (energy power) object controller prototype to interface with ERTMS balises, signals and track circuits on areas far from stations.
		Track vacancy detection SWOC		2021	2022	DE	6	Track Vacancy Detection (axle counters) with optional signal management and with safe and secured communication over wireless networks.
		Verification of Multiple Networks Scalable SWOC		2021	2022	IT	6	A prototype of wayside object controller that will be able to communicate using the available heterogeneous wireless public networks (e.g. 2G/3G/4G, satellite, ...)
		Verification of SWOC network for managing WOs demonstrator		2021	2022	N/A	6	SWOC and a Wireless Sensor Network for a safe and secure communication as well as transparent routing for the IXL to the object to be controlled.
		Verification of a LX Smart wayside objects		2021	2022	CZ	6	SWOC connected via radio connection to the IXL or to the level crossing (LX) controller to control wayside objects commonly used at an LX – axle counter, gate signal, warning light, light signal or barrier drive.
		Verification of SWOC for points machines		2021	2022	ES, DE	6	Controlling of point machines with wireless communication, advanced diagnostic features, optimized distribution, low power consumption + autonomous power supply and storage
		Verification of adaptable Wireless sensor Network for way side objects		2021	2022	FR	6	New generation of low-power and resource-constrained wireless sensor networks (WSN) for adaptive data collection and forwarding for railway environment

IP	Research Area	Specific Technological demonstration of	characteristics					Overall high level focus/objective
			Market	Testing time - YEAR start	Testing time - YEAR end	Country	TRL	
IP3	TD3.1 Enhanced Switch & Crossing System Demonstrator	RAMS optimised S&C	Generic	2019	2023	AT	7	Monitoring programme for S&C including: Geometry and overrunning, casting, novel rail grade, resilient pads, rail fastening system, base plates, switch roller system, etc.
		cast manganese frog with welded bainitic component		2020	2023	FR	7	Experimental evaluation of fatigue of cast manganese-crossing for welding technology to join bainitic with pearlite steel components.
	TD3.2 Next Generation Switch & Crossing System Demonstrator	Low N&V Tramway Crossing	Urban/Suburban	2021	2023	AT	6	Test overall performance of a girder rail swing nose crossing in service for the reduction of N&V
		Autonomous inspection of S&C using drone technology	Generic	2021	2023	UK	6	Use of drones to undertake basic visual inspection and potentially supervisor inspections of S&Cs, specifically in areas non-accessible or visible by other means
		Autonomous repair of S&C using additive manufacturing techniques	Generic	2021	2023	UK	6	Discrete Defect repair (DDR) unit being applied to the automated restoration of worn/ damaged crossings.
		Materials and Components	Generic	2019	2023	UK, SE, FR	4/7	Next generation S&C materials and components tests (i.e. adjustable fastening systems)
		Vertical moving switch	Urban/Suburban	2022	2023	SE	7	New vertical moving switch addressing the main issues of classic horizontal movement of the frog
	TD3.3 Optimised Track System	Transition zone	Generic	2019	2023	SE	5/6	tests on improvement of the transition between open track and bridges, open track and S&C, ballasted track and slab track
		new slab track		2019	2023	SE	7	test of a Modular Slab track solution reducing maintenance costs
		Innovative use of materials		2019	2023	AT	5/6	test of innovative use of materials and advanced manufacturing techniques
		Laser clad coating on rails		2020	2023	AT	5/6	test of laser clad coatings on rails nearby and on rail joints; laser hardening and laser cladding of worn rail zones
	TD3.4 Next Generation Track System	Contactless EMAT ultrasonic defect detection	Generic	2020	2023	FR	6	Contactless ultrasonic method to identify rail-level defects using the EMAT method
		Rail Defect Repair		2020	2023	UK	7	Thermocouple instrumented trials on process for different rail steel grades
	TD3.5 Proactive Bridge and Tunnel Assessment, Repair and Upgrade Demonstrator	Tunnel improvements	Generic	2020	2023	FR, UK	7	Reduce track and tunnel closure by offsite manufacturing and increase quality
				2020	2023	AT	7	Predict calcite clogging over time
		Bridge improvements	Urban/Suburban	2020	2023	DE	6	Efficient monitoring of noise emission and installation of passive noise dampers.
			Generic	2020	2023	UK	7	Extend bridge service life by lowering fatigue
				2021	2023	SE	7	Increase bearing capacity and remaining fatigue life of concrete bridges and increasing safety.
			High Speed	2020	2023	SE	7	Make high speed traffic possible on existing bridges with proven dynamic properties
	Integrated Technological Demonstrators Asset Management (TD3.6, TD3.7, TD3.8)	Strategic long-term	Generic	2021	2022	PT, UK	6	Test of a strategical decision support tool based on the tactical planning tool
		Tactical and Operational short term		2021	2022	UK, SE DE NL, ES, FR	6/7	maintenance process and strategies through knowledge extracted from information coming from available data and monitoring systems
		Metro/ Tram Asset Management	Urban/Suburban	2021	2022	IT	7	Demonstrator focusing on minimising maintenance costs, optimising the use of resources while maximising network

IP	Research Area	Specific Technological demonstration of	characteristics					Overall high level focus/objective
			Market	Testing time - YEAR st	Testing time - YEAR en	Country	TRL	
IP4	Integrated TDs of all IP4 ecosystem	Towards the MaaS concept	Shared modes and on-demand	2021	2023	GR,IT,FI,CZ	6/7	Test of a scalable eco-systems which enables pan European multimodal travels and MaaS. Demonstration of the functional ecosystem with the full integration of Ride-sharing and MaaS. Scalable (near-) market ready eco-systems enables pan European intermodal travels and MaaS, including cross-platform approaches.
		Fully dynamic door-to-door travel	Multimodal (rail, bus, metro,...)	2022	2023	IT, GR, HR, ES, CZ, PL	6/7	Demonstrations of IP4 technologies in 6 different locations involving different transport operators, translating/combining IP4 solutions into specific demo sites solutions:
IP5	TD5.1 Fleet Digitalization and Automation	Condition based maintenance	Freight	2020	2022	DE	6/7	End-to-end solution for predictive maintenance, including processes, data handling, analytics and dashboards, for locomotives and wagons.
	TD5.2 Digital Transport Management	Improved terminals		2021	2023	SE	6	A gate equipped with intelligence as part of a connected decision platform optimizing the work process in a terminal. Sata exchange platform to ensure efficiency and security (of data handling) in the transport chain. Equipment prototypes with HMI interface validated in live demonstration for a selected large and complex terminal.
	TD5.3 Smart Freight Wagon Concepts	Core market wagon		2022	2023	SK / SE	6/7	Modular, logistics-capable and cost-efficient, low weight, high-payload and aerodynamically optimised freight wagons
		Extended Market Wagon		2022	2023	TBD	5/6	Modular, logistics-capable and cost-efficient, low weight, high-payload and aerodynamically optimised freight wagons
		Telematics		2021	2022	SE	7	Demonstration activities of the intelligent wagon based on telematics and electrification
	TD5.4 New Freight Propulsion Concepts	Hybrid / advanced Propulsion		2021	2022	DE, SE	6/7	Demonstration of distributed power (3 Locos) technology developed using LTE with a 700 m heavy coal freight train with loco at the end of the train being remote controlled. Second demonstrator 835 m train.

Annex V – List of Founding Members of the Europe’s Rail Joint Undertaking

NAME OF MEMBER		REGISTRATION DETAILS
1	Administrador de Infraestructuras Ferroviarias (ADIF), Entidad Pública Empresarial	public corporate company registered under Spanish law (registration number: Q2801660H), with its registered office at Calle Sor Ángela de la Cruz, 3, 28020 Madrid, Spain
2	Alstom Transport SA	registered under French law (registration number 389 191 982), with its registered office in 48, rue Albert Dhalenne, 93482 Saint-Ouen, France
3	ANGELRAIL consortium led by MER MEC S.p.A.	registered under Italian law (registration number: 05033050963), with its registered office in Via Oberdan 70, 70043 Monopoli (BA), Italy
4	AŽD Praha s.r.o.	registered under Czech law (registration number: 48029483), with its registered office in Žirovnická 3146/2, Záběhlice, 106 00, Praha 10, Czech Republic
5	Construcciones y Auxiliar de Ferrocarriles, S.A. (CAF)	registered under Spanish law (registration number: Volume 983, Folio 144, Sheet number SS-329, entry 239 ^a), with its registered office in calle José Miguel Iturriz n° 26, 20200, Beasain (Gipuzkoa), Spain
6	Asociación Centro Tecnológico CEIT	registered under Spanish law (registration number: 28/1986 Registry of Associations of the government of the autonomous community of the Basque Country), with its registered office in Paseo Manuel Lardizabal, n° 15. Donostia-San Sebastián, Spain
7	České dráhy, a.s.	registered under Czech law (registration number: 70994226, entered in the Commercial Register kept by the Municipal Court in Prague, section B, insert 8039), with its registered office in Prague 1, Nábřeží L. Svobody 1222, postal code 110 15, Czech Republic
8	Deutsche Bahn AG	established in Potsdamer Platz 2, 10785 Berlin, Germany
9	Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)	registered under German law (registration number: VR 2780 at Amtsgericht Bonn), with its registered office in Linder Höhe, 51147 Cologne, Germany
10	European Smart Green Rail Joint Venture (eSGR JV), represented by Centro de Estudios de Materiales y Control de Obra S.A (CEMOSA)	registered under Spanish law (registration number: A-29021334), with its registered office in Benaque 9, 29004 Málaga, Spain
11	Faiveley Transport SAS	registered under French law (registration number 323 288 563 RCS Nanterre), with its registered office in 3, rue du 19 mars 1962, 92230 Gennevilliers, France
12	Ferrovie dello Stato Italiane S.p.A. (FSI)	registered under Italian law (registration number: R.E.A. 962805), with its registered office in Piazza della Croce Rossa 1, 00161 Roma, Italy

NAME OF MEMBER		REGISTRATION DETAILS
13	Hitachi Rail STS S.p.A.	registered under Italian law, registration number R.E.A. GE421689, with its registered office in Genova, Italy
14	INDRA SISTEMAS S.A & PATENTES TALGO S.L.U.:	
	INDRA SISTEMAS S.A.	registered under Spanish law (registration number: A-28599033), with its registered office in Avenida de Bruselas nº 35, 28108 Alcobendas, Madrid, Spain
	PATENTES TALGO S.L.U.	registered under Spanish law (registration number: B-84528553), with registered office in Paseo del tren Talgo, nº 2, 28290 Las Rozas de Madrid, Madrid, Spain
15	Jernbanedirektorate (Norwegian Railway Directorate)	established in Biskop Gunnerus gate 14A, 0185 Oslo, Norway
16	Knorr-Bremse Systeme für Schienenfahrzeuge GmbH	registered under German law (registration number: HRB91181), with its registered office in Moosacher Str. 80, 80809 München, Germany
17	Österreichische Bundesbahnen-Holding Aktiengesellschaft (ÖBB-Holding AG)	registered under Austrian law (registration number: FN 247642f), with its registered office in Am Hauptbahnhof 2, 1100 Wien, Austria
18	Polskie Koleje Państwowe Spółka Akcyjna (PKP)	registered under Polish law (registration number: 0000019193), with its registered office in Aleje Jerozolimskie 142A, 02-305 Warszawa, Poland
19	ProRail B.V. & NS Groep N.V.	
	ProRail B.V.	registered under Dutch law (registration number: 30124359), with its registered office at Moreelsepark 3, 3511 EP, Utrecht, The Netherlands
	NS Groep N.V.	registered under Dutch law (registration number: 30124358), with its registered office at Laan van Puntenburg 100, 3511 ER, Utrecht, The Netherlands
20	Siemens Mobility GmbH	registered under German law (registration number HRB 237219), with its registered office in Otto-Hahn-Ring 6, 81739 Munich, Germany
21	Société nationale SNCF, société anonyme	registered under French law (registration number: 552 049 447), with its registered office in 2 Place aux Étoiles, 93200 Saint-Denis, France
22	Strukton Rail Nederland B.V.	registered under Dutch law (registration number: 30139439 Chamber of commerce Utrecht), established in Westkanaaldijk 2, Utrecht Postbus 1025, 3600 BA Maarssen, The Netherlands
23	THALES SIX GTS France SAS	registered under French law (registration number: 383 470 937), with its registered office in 4 Avenue des Louvresses, 92230 Gennevilliers, France
24	Trafikverket, a Public Sector Body	registered under Swedish law (registration number: 202100-6297), with its registered office in 781 89 Borlänge, Sweden

NAME OF MEMBER		REGISTRATION DETAILS
25	Voestalpine Railway Systems GmbH	registered under Austrian law (registration number: FN 126714w), with its registered office in Kerpelystrasse 199, 8700 Leoben, Austria

Annex VI – System Pillar and Innovation Pillar interactions

*This note sets out **an indicative proposition** for the requirements for the System Pillar and Innovation Pillar to inform the development of the EU-RAIL Multi Annual Work Programme. The deliverables may change through the ongoing EU-RAIL preparatory work, but should be taken as a guide of the type of outputs required from the System Pillar and Innovation Pillar in EU-RAIL, and resource planned accordingly. This document will be finalised as a basis for the work to be carried out within EU-RAIL.*

The EU-RAIL, through the System Pillar (SP) will aim to have a coherent approach to the evolution of the European rail system through a system architecture approach.

The SP has a discrete work scope to set the system architecture of the rail system (Task 1), and in particular the CCS+ architecture (Task 2), as well as coordinating the standardisation and TSI outputs of the EU-RAIL. While the main focus will be on these two Tasks, the System Pillar will have to integrate and duly considered other key subsystems, such as digital automatic coupling as enabler of future much more performant rail cargo, interfaces to urban mobility, and energy systems.

For CCS, EU-RAIL will develop the operational concept(s) and functional system architecture for a genuine integrated European CCS system, with much greater standardisation, a wider scope (described as CCS+ at this time), aiming at no variation compared to present.

The Innovation Pillar (IP) will deliver, through research and innovation, advances in, *inter alia*, advanced traffic management, digital and automated train operations, and rail freight.

A structured and continuous interaction between SP and IP will be necessary to achieve the overall objectives of EU-RAIL, as well as how the system work performed within the IP would integrate and remain consistent with the SP.

This note aims to set an approach for this detailed collaboration taking into account the high-level functional architecture and principles included in the system pillar report, as well as the current proposals received from the IP Flagship areas.

When there is existing available TSI regulations or standards for these topics, the works both from the SP and the IP will be based on them and updates or modifications would be proposed instead of new drafting proposals.

As further definitional work on the system approach is carried out, there will be additional system-led requirements which may impact the work of the IP, and outputs from the IP that will influence the system architecture. It is therefore necessary to allow flexibility in definition of IP and SP outputs through the time frame of the JU. Procedures and plans that include relevant milestones referring to the activities of the SP will be identified for each Flagship Area interacting with the SP and vice versa. In addition, the necessary Supervision and Change Management will be anticipated including organisation of regular review meetings.

According to the System Pillar Report SP and IP have different roles

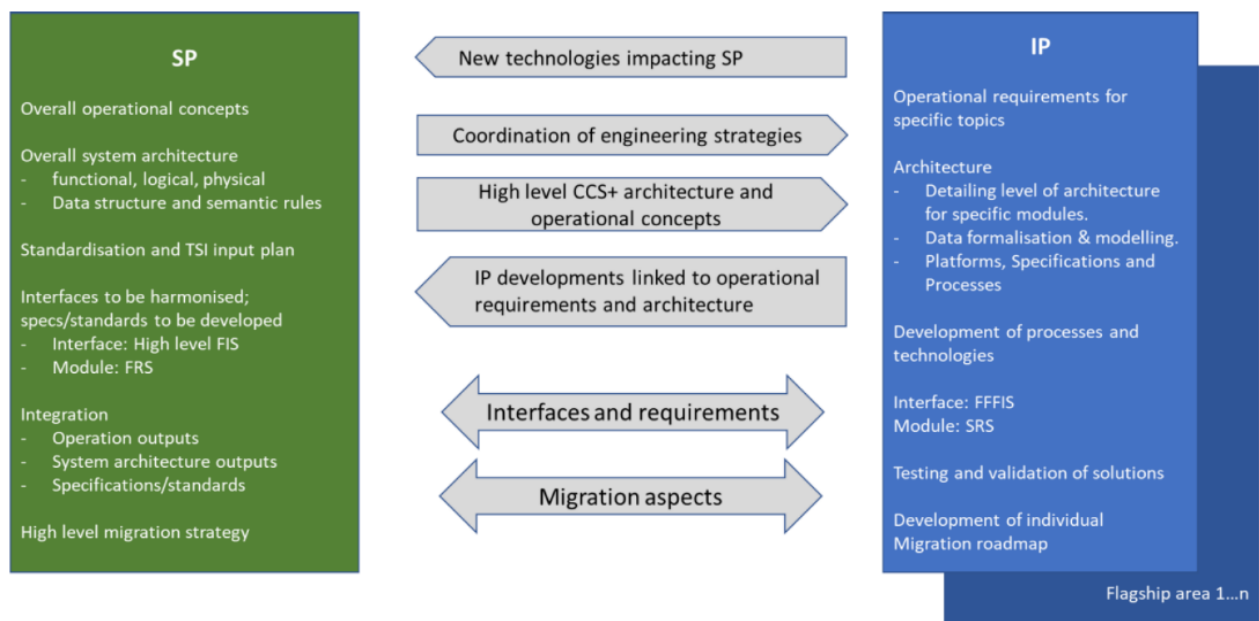


Figure 1 - Relationship between the Innovation Pillar and the System Pillar

The following descriptions set out for the Innovation Pillar Flagship Areas the expected split of roles between the Innovation Pillar and System Pillar.

FA1

Includes outcomes to improve strategic and tactical planning of rail network (planning), develop resilience of a connected “real time” rail network (operation) and integrate rail traffic within door-to-door mobility.

SP	IP
<ul style="list-style-type: none"> • Traffic management principles, top-level requirements and use case scope • Functional and non-functional requirements for network disturbance resolution • Functional requirements for on demand traffic management 	<ul style="list-style-type: none"> • Specifications for planning tools and interfaces for: <ul style="list-style-type: none"> ○ Rolling planning and TTR ○ Decision support for short term planning; ○ Optimization methods for capacity efficiency and energy saving; ○ feedback loops from operations • Technical specifications and functional/non-functional requirements for operation tools and interfaces (including with the control and command layer) for: <ul style="list-style-type: none"> ○ Automation and decision support; ○ Improved real-time connection of the networks; ○ Real-time convergence between planning & ope.

- Dispatching and Incident management
- Disruption management
- Conflict detection & resolution
- Speed regulation and dynamic timetables;
- Real-time crew / rolling stock dispatching

It is to be highlighted that this is the main layer that has been included within the CCS+ extended scope so it is expected that the outcome of the works in this topic from EU-RAIL will include sufficient regulations and standards for integrated European rail traffic management. The basis for this will be the existing regulations on telematic applications for freight and passenger services TSI.

SP	IP
<ul style="list-style-type: none"> • Traffic management cross-border operational principles • Operational and architecture concept for an European TM including operational requirements and CCS principles 	<ul style="list-style-type: none"> • System requirements for Cross boarder scheduling, traffic flow optimisation and deviation management • Interface specifications and data set for interoperable connected TMS • Interface specifications and data set to integrate rail traffic within door-to-door mobility

FA1+FA2

FA2 also considers as a priority the interface of their outputs with the TMS and demand-orientation and network capacity improvement technologies. Also, FA2 includes outcomes related to route setting methodologies related also between the traffic management layer and the control trains layer. It is understood that there will be a coordination between these FA on these topics.

In terms of ERTMS, FA 1 & 2 shall design a CCS trackside and CCS onboard functionality as a simplified technical environment for an efficient ERTMS rollout in Europe based on the harmonized operational concept provided by SP. This includes the simplification of the trackside architecture and its migration as well as the higher grade of automation for the toolchain needed for CCS system planning, configuration engineering, monitoring, etc. It may require reconsidering the distribution of the “intelligence” between onboard, track-side and European central oversight as designed in FA1. The effort for rolling out ERTMS shall be strongly reduced by designing functionality without needs for high expert skills, configuration workload or detailed special safety cases per installation. Upgrades for trackside and vehicle ERTMS functions shall be simplified by operational, architectural and functional optimisation of the technical ERTMS environment or its components.

SP	IP
<ul style="list-style-type: none"> • Functional requirements and operational concept for the interface between Operate railway system and 	<ul style="list-style-type: none"> • Technical specifications for planning tools and interfaces (including with the control and command layer) for:

Control & command railway system layers	
<ul style="list-style-type: none"> • high level signalling principles including the list of potential types of routes and what are the rules for locking, monitoring, releasing and blocking the routes • Users requirements and physical and logical architecture to identify the correct level of modularity required for the related modules • Harmonized operational concept and requirements for a homogeneous, economic and simplified use, rollout, or change of radio-based ERTMS applications 	<ul style="list-style-type: none"> ○ Integration ATO/TMS to improve capacity; ○ ATO journey profiles for timetabling • Technical specifications for operation tools and interfaces between control command and signalling and traffic management for automated and digital train operation • system requirement specifications for the systems that will define the routes and control the train movements in consequence. • interface specification of the system <ul style="list-style-type: none"> ○ harmonised expected input from the timetables functions ○ harmonised expected outputs towards the trackside function that allows to control trains ○ logical and physical interfaces based on SP architecture

Also, strong collaboration is expected between FA1 and FA2 as regards the function to Manage railway stations & depots. Higher standardisation and harmonisation in the operations for stations & depots will increase performance of the railway system in its interface with the customer. Both FA1 and FA2 have outcomes related to terminals.

SP	IP
<ul style="list-style-type: none"> • CCS principles, operational concept, functional architecture and requirements for specific railway areas like shunting yards, shunting zones in stations, depots, terminals and connected industry areas 	<ul style="list-style-type: none"> • FA1. System requirements and data set interfaces for the connection TMS & CTC, and automated yards • FA1. Data set and interfaces for the Integration with yard and station management • FA2 Engineering rules for terminals • FA2 Operational rules for movements in terminals

FA2

Includes outputs for an overarching automation process and ATP evolution & optimisation. ATP and DATO are to be designed and evolved building on the same supporting functions and infrastructure, such as high-precision localization, digital topology information, safe computing platforms, on-board communication networks, train-to-train and train-to-ground communication. In addition, combination of ETCS hybrid Level 3 or full moving block and DATO will be key to increase the capacity of railway lines.

These outputs are part of the technical scope of the CCS+ function which contains the infrastructure and on-board functions to control the train movements. Following the principles included in the system pillar report the following deliverables would be expected:

SP	IP
<ul style="list-style-type: none"> Operational concept for digital automatic train operation both for nominal and degraded operations Further detailing in the architecting (concluding for example if there is or how a direct link between TMS and ATO) 	<ul style="list-style-type: none"> Updated specifications for GoA3/4: <ul style="list-style-type: none"> System requirements Requirements for the communication channel Requirements for diagnose Communication layers Interfaces ATO-ETCS + ATO-TCMS + ATO-trackside Unique set of engineering rules to deploy the different stages for DATO (see the demonstrators in FA2)

In particular, for the outcome related to harmonised supporting functions for localization, FA2 includes an outcome such as safe absolute near real-time train positioning techniques

SP	IP
<ul style="list-style-type: none"> Architecture that implements the flexible combination of a mix of trackside sensor and onboard localisation systems. Collection of the set inputs from the CCS TSI 2022 work (e.g. from the TWG architecture) performance requirement targets for the next evolution of localization systems 	<ul style="list-style-type: none"> develop solutions that would allow for high-precision localization, digital topology information and safe absolute near real-time train positioning techniques. FFFIS odometry platform (enhanced train localisation interface between technology independent sensors and the EVC)

FA 2 also highlights that for the expected output, safe unattended operation must be ensured by comprehensive, modular, and scalable perception systems (onboard and trackside) for both outdoor & indoor environments. Including also for the onboard side new generation of brake systems and new methods for qualification of brake performance under degraded adhesion. This relates in the draft CCS+ architecture to the functions of control signalling devices and manage train interfaces which are key in some of the central interfaces of the CCS+ system of interest and the related systems. Hence, modularity and interface standardisation is expected within this scope.

SP	IP
<ul style="list-style-type: none"> Operational model and requirements Functional, logical and physical architecture identifying the list of signalling devices that the CCS+ layer will control 	<ul style="list-style-type: none"> Specifications for the interfaces of the trackside CCS system to the TMS, train, trackside assets and trackworker safety systems

- | | |
|---|---|
| <ul style="list-style-type: none"> • Operational concept for the signalling devices (signalling principles) • Open points from topical working group architecture for CCS TSI 2022: <ul style="list-style-type: none"> ○ Including functional allocation between control command train and offer rollingstock (e.g odometry, TDC, shared data services, cyber, DAC interface) | <ul style="list-style-type: none"> • FFFIS for signalling devices • (updated) system requirements for braking • Revised FIS/FFFIS of the train architecture based on the innovative solutions developed in EU-RAIL |
|---|---|

FA3

Task 2 linked: Includes results related to functional modules already identified in the SP report within the system of interest for the CCS+. This assumes that the maintenance & renew functional module included in the operate railway system layer is the responsibility of FA3 (to be confirmed).

SP	IP
<ul style="list-style-type: none"> • Maintenance & renew principles (for HW and SW assets) • Identification of functionalities within this module part of the CCS+ • Functional requirement for interface between function manage traffic and function execute maintenance & renew • Functional requirement for interface between function Control & Command trains (infrastructure & trains) and function execute maintenance & renew 	<ul style="list-style-type: none"> • FA3 System Requirements for the CCS+ functionalities of the intelligent asset management system – linked to maintenance and renew functional module. • FA1+FA3 Interface specifications between the intelligent asset management system and the Operation and traffic management system • Interface specifications between the intelligent asset management system and the TR CCS (ATP Trackside, ATO, Object Controllers) • Interface specifications between the intelligent asset management system and the OB-CCS

FA3 foresees an operational outcome related to the Information sharing across the supply chain and TMS. The identification of the necessary data and the best capture methods are expected from FA3 to input the conceptual data model in the SP and the complete data architecture in TT. This is further described in the section transversal to all FA and that is also applicable to TT.

Task 1 linked: For other results expected in this FA, contributions to the rail system architecture and operational concept are expected for the task 1 of the SP.

SP	IP
<ul style="list-style-type: none"> • Functional, logical and physical architecture • Overall operational concept 	<ul style="list-style-type: none"> • description of the specific developments <u>linked to the operational requirements or system architecture</u> including Unmanned and non-invasive monitoring and inspections, Advanced and holistic asset decisions; Advanced and holistic design and homologation of assets; Remotely controlled, unmanned and metadata-assisted interventions • economic assessments for some of these developments • global simulation results for some of the developments or some specific results of the foreseen demonstrators

FA4

Task 2 linked: FA4 Includes outputs and results relevant for the related systems to the CCS+ identified within the SP system architecture proposed. This mainly involves the energy management considerations for the functions manage traffic and control trains. However, the expected inputs from the IP to the SP can be found both in FA1 and FA4 to be detailed in which FA the work will be done or if it will be a combined taskforce.

SP	IP
<ul style="list-style-type: none"> • Energy savings principles and targets for traffic management • Decisions on level of requirement and modularity necessary for any input to the standardisation and TSI input plan as regards the energy savings functionalities 	<ul style="list-style-type: none"> • Specifications for planning tools and interfaces for: <ul style="list-style-type: none"> ○ Optimization methods for capacity efficiency and energy saving; [FA1/FA4] ○ feedback loops from operations [FA1/FA4] for the part related to energy • Technical specifications for operation tools and interfaces (including with the control and command layer) for: <ul style="list-style-type: none"> ○ FA1 <ul style="list-style-type: none"> ▪ Automation and decision support; ▪ Dispatching and Incident management ▪ Disruption management

- Conflict detection & resolution
- FA4
 - Energy savings module specifications and interfaces to these functions including for a real time timetabling

The outputs related to advanced environmental data management foreseen in this FA are of interest to the data structure. These are described in the section transversal to all FA and that is also applicable to TT.

Task 1 linked: For other of the results expected in this FA, contributions to the rail system architecture and operational concept are expected for the task 1 of the SP.

SP	IP
<ul style="list-style-type: none"> • Functional, logical and physical architecture • Overall operational concept 	<ul style="list-style-type: none"> • description of the specific developments <u>linked to the operational requirements or system architecture</u> including alternative energy solutions for RS, energy management of the stations, alternative fuels for railways, systems improvement for low consumption emissions noise and vibrations, or systems for a healthier railways • economic assessments for these developments • global simulation results of the developments or the results of the foreseen demonstrators

FA5

Task 2 linked: Previous sections in this document include the expectations on FA1 and FA2 as regards the function to Manage railway stations & depots. Higher standardisation and harmonisation in the operations for stations & depots will increase performance of the railway system in its interface with the customer. Outcomes included in FA5 will collaborate to this objective

SP	IP
<ul style="list-style-type: none"> • CCS principles, operational concept, functional architecture and requirements for specialized railway areas like shunting yards, shunting 	<ul style="list-style-type: none"> • FA1. System requirements and data set interfaces for the connection TMS & CTC, and automated yards

zones in stations, depots, terminals and connected industry areas

- FA1. Data set and interfaces for the Integration with yard and station management
- FA2 Engineering rules for terminals
- FA2 Operational rules for movements in terminals
- FA5 system requirements for automation components such as automated/automatic brake test system or automated parking brake system.
- FA 5 system requirements and data set interfaces for the Waggon identity system and Yard automation equipment and tools

Task 1 linked: FA5 includes a main objective to improve the seamless Rail freight which has several outcomes relevant for the CCS+ system of interest in its layer or interface to the traffic management. The expectations between SP and IP are therefore built on the table included previously for FA1.

SP	IP
<ul style="list-style-type: none"> • Operational and architecture concept for an European TM including operational requirements and CCS principles 	<ul style="list-style-type: none"> • FA1 System requirements for Cross boarder scheduling • FA1 Interface specifications and data set for interoperable connected TMS • FA1 Interface specifications and data set to integrate rail traffic within door-to-door mobility • FA5 system requirements for freight automatic cross-border slot finding • FA5 freight requirements for seamless traffic management planning and operation

Migration towards the target system foreseen in the EU-RAIL for freight sector is included as a challenge in the FA5 document. SP expects to deliver a Railway system architecture migration roadmap and to achieve this, it is expected from FA5 a specific migration roadmap for the target system in specific for freight.

The outputs related to freight data foreseen in this FA are of interest to the data structure. These are described in the section transversal to all FA and that is also applicable to TT.

For other of the results expected in this FA, contributions to the rail system architecture and operational concept are expected for the task 1 of the SP.

SP	IP
<ul style="list-style-type: none"> • Functional, logical and physical architecture • Overall operational concept 	<ul style="list-style-type: none"> • description of the specific developments <u>linked to the operational requirements or system architecture</u> including DAC type 4&5 and hybrid, new telematic solutions, Checkpoints at borders or other operational stop points, rostering concepts • economic assessments for these developments • global simulation results of the developments or the results of the foreseen demonstrators

FA6

Task 2 linked: As mentioned by the FA6, the survival of regional lines and fleet depends on their economic viability. From the SP is therefore expected that this is evaluated at a rail system level including both the infrastructure and the vehicles. Hence the initial expectations from the SP to this FA focuses on the identification of the architecture elements and operational principles that would allow to achieve this economic viability.

SP	IP
<ul style="list-style-type: none">• Functional, logical and physical architecture including the list of signalling devices that the CCS+ layer will control and the different CCS+ modules onboard<ul style="list-style-type: none">◦ (After interaction with FA6 economic assessment and migration considerations) target CCS+ regional architecture that includes the subset of the functions, interfaces and components included in the overall SP architecture that are sufficient for the regional operation and that optimise this economic viability• Architecture migration roadmap• Operational concept	<ul style="list-style-type: none">• economic assessments for optimising economic viability with the SP architecture in the regional lines<ul style="list-style-type: none">◦ Criteria to define the minimum functions, modules, interfaces and constituents that will optimise economic viability for regional services• Asset-lifecycle, production process and device designs (incl. simplified configuration onboard and trackside) compliant to the architecture interfaces and principles of FA1 and 2 that fulfil the economic requirements• As-is analysis of the current systems on regional lines for the traffic management and CCS layers. Including their characteristics description that will allow for the next steps of migration towards the digital identified target regional system<ul style="list-style-type: none">◦ Including for example interface with the existing interlocking and the issues of migration for these towards the target regional CCS+ architecture

Transversal to all FA and applicable to TT

Conceptual data model. Process and architecture models

Building of a common data model for the railway system is within the scope of the EU-RAIL. As regards CCS+, within the draft functional architecture there are several interfaces between the different functions corresponding to the system of interest yellow boxes and also between the functions in the system of interest and the related systems shaded yellow boxes. These would be the priorities for the data inclusion in the model

SP	IP
<ul style="list-style-type: none"> • conceptual data model at least for the interfaces between the different functions included in the CCS+ scope and the interfaces of the CCS+ functions and the related systems • Functional, logical and physical architecture • Standard framework for process specification and modelling for a centralized model integration (including assurance) • Principles and method for master data management, data flows and registries (e.g. functional track network topology) 	<ul style="list-style-type: none"> • all the FA to contribute with detailed set of data flow and structures necessary • TT supports the collection of data flows and structures for this set of data and provides an integrated conceptual data model for the functional, logical and physical architecture. For this TT provides a modelling service and interface for the architectural process and assures the model integrity. • Centralized ontology register and change management/governance process • Centralized modelling platform (also as a extranet service) • TT solutions supporting the data gathering, transmitting, storage and managing that main IM and RU are doing (including where possible automatic acquisition of the data) • Specification and demonstrator for the digital register (important basis for digital twins) • Standard framework as regards Digital Twins for process specification and modelling for a centralized model integration (including assurance)

Continuous integration of results into a simulated architecture: model checking

In addition to the data model that will include at least the interoperable data, a digital model (or partly also simulations or implementations) which is a virtual representation able to imitate the behaviour of the railway system during the spans its lifecycle is expected from TT. This should enable continuous integration, maturity assessments, virtual certification and validation of systems or specifications. Requirements and results for these are also expected by the SP.

Mutual waiting for results between higher and lower architectural design levels or between different functions shall be avoided. A continuous integration process shall be defined, monitored by the System Pillar and continuously simulated in TT that allows top-down and bottom-up integration of FA and SP results in parallel.

This continuous integration process shall allow the fast development of single functionalities as single isolated models or prototypes (based on a standard TT framework), but also shall assure their later integration into a testable model simulating the overall CCS+ or railway system architecture. The depth and functional completeness of the model shall correlate to the integration validation needs defined

by the System Pillar. The model shall be designed as a continuous laboratory that also supports the change request evaluation.

The centralized architecture model service a necessary instrument for continuous integration have a high importance for achieving the System Pillar targets and the end-to-end quality of the architecture. Because of this the interaction process of SP and TT shall be close and shall base on an agile workflow management.

SP	IP
<ul style="list-style-type: none"> • Defines integration and validation needs and depth for the implementation of the digital twin • Monitors the continuous integration process incl. the maturity of integration 	<ul style="list-style-type: none"> • TT defines a standardized framework for the development of prototypes that can be integrated into a full-system digital twin based on a continuous integration process. • TT provides a centralized digital twin laboratory (at least for CCS+) for integration validation of prototypes, that may developd as isolated solution at first. Out of systematic test-driven development of the digital twin the lab generates reports about integration problems. The test definitions are delivered by FA1-6.

Additional considerations

These expectations from SP and IP are related to the expected deliverables from the technical scope of the system. However, there are other aspects that are expected both from the SP and IP and that are critical to achieve the objectives set out in the EU-RAIL. The following are the ones that are common for the different technical scopes within the CCS+:

- Regarding migration, SP will deliver target system(s) together with the stable intermediate steps to reach there. For this, it would be expected to receive from the IP in some cases the details of the technical solutions as they are now. Also, the revision of the stable intermediate steps will be reviewed by the IP to align with the roadmap of their innovative solutions
- Maturity records or pilots for different innovative solutions are to be monitored by the system pillar. The design of such pilots should be aligned with the operational concept and functional architecture of the system pillar, so iteration between pillars should be expected. In addition, and as part of the results of these pilots, it is expected from the IP to develop the testing and validating requirements necessary to evaluate the success of the demonstrator but also to test and validate the innovative solutions once they are included in the regulations or standards. This would include the testing requirements for the new developed functions but also if necessary, the update testing requirements for any development of existing functionality (e.g. with ETCS)
- SP will define principles about data exchange, communication methods, function and service design and interface design for all interfaces that are standardized.
- Regarding requirements, SP will derive top-level requirements from the operational concepts and the identified pain-points or opportunities and will break them down to process and

architectural requirements. IP will design compatible system requirements that fulfil them. As a part of the validation process the correctness of this requirement deduction will be traced by the SP.

- To structure the architectural integration process the SP will define integration milestones and their validation targets.

At this stage, there is no agreed detailed architecture and no logical or physical agreed architecture approach for CCS+. Hence when we are referring to an FFFIS, this does not only mean that a physical interface is expected but this can also result in a SW interface for example. The concept of the modular safety platform for several uses is also foreseen to be further analysed. The level of detail on the interfaces and modularity needs to be discussed and agreed, including a consideration of the business and economic impact.

Once the deliverables proposed in this technical note are discussed and agreed, they will be the first input to the standardisation and TSI input plan that the system pillar needs to develop. Also, in all the different points included in this note, a standardisation proposal or a change request to a TSI will be drafted by the SP taking into account the input from the IP. These deliverables are key to the role of the System Pillar as 'generic system integrator' for the EU-RAIL.

Annex VII – 2022 Call for proposals

EU-Rail has to deliver a high capacity integrated European railway network by eliminating barriers to interoperability and providing solutions for full integration, covering traffic management, vehicles, infrastructure and services, aiming to achieve faster uptake and deployment of projects and innovations. That should exploit the huge potential for digitalisation and automation to reduce rail's costs, increase its capacity and enhance its flexibility and reliability, and should be based upon a solid reference functional system architecture shared by the sector, in coordination with the European Union Agency for Railways.

The European Green Deal objective is to reach climate neutrality by 2050, the Fit for 55 package sets medium-term greenhouse gas emissions reduction objectives, and the Digital Decade sets the path to bring Europe to the forefront of digitalisation and automation.

The Sustainable and Smart Mobility Strategy articulates the pathways towards digitalising and greening the transport sector and sets specific milestones for the railway sector.

The railway sector will contribute to those objectives by increasing its capacity for passenger and goods transport, enabling an increase in the use of rail transport, and by reducing further the greenhouse gas emissions of the railway sector itself.

In order to foster the transformation of the railway system, the EU encourages research and innovation with its new EU Framework Programme for Research and Innovation - Horizon Europe.

The objectives of EU-Rail have been set to address the EU policy objectives, rail sector vision, and the challenges inherent to the transformation of the rail system as set in its Master Plan²⁶ and Multi-Annual Work Programme²⁷.

The general objectives, as set out in the Single Basic Act are:

- (a) contribute towards the achievement of the Single European Railway Area;
- (b) ensure a fast transition to more attractive, user-friendly, competitive, affordable, easy to maintain, efficient and sustainable European rail system, integrated into the wider mobility system;
- (c) support the development of a strong and globally competitive European rail industry

The Specific objectives to the partnership are to:

- (a) facilitate research and innovation activities to deliver an integrated European railway network by design, eliminating barriers to interoperability and providing solutions for full integration, covering traffic management, vehicles, infrastructure also including integration with national gauges, such as 1520, 1000 or 1668 mm railway, and services, and providing the best answer to the needs of passengers and businesses, accelerating uptake of innovative solutions to support the Single European Railway Area, while increasing capacity and reliability and decreasing costs of railway transport;
- (b) deliver a sustainable and resilient rail system: by developing a zero-emission, silent rail system and climate resilient infrastructure, applying circular economy to the rail sector, piloting the use of innovative processes, technologies, designs and materials in the full life-cycle of rail systems and developing other innovative solutions to guided surface transport;

²⁶ Master Plan available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

²⁷ MAWP available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

- (c) develop through its System Pillar a unified operational concept and a functional, safe and secure system architecture, with due consideration of cyber-security aspects, focused on the European railway network to which Directive 2016/797²⁸ applies, for integrated European rail traffic management, command, control and signalling systems, including automated train operation which shall ensure that research and innovation is targeted on commonly agreed and shared customer requirements and operational needs, and is open to evolution;
- (d) facilitate research and innovation activities related to rail freight and intermodal transport services to deliver a competitive green rail freight fully integrated into the logistic value chain, with automation and digitalisation of freight rail at the core;
- (e) develop demonstration projects in interested Member States;
- (f) contribute to the development of a strong and globally competitive European rail industry;
- (fa) enable, promote and exploit synergies with other Union policies, programmes, initiatives, instruments or funds in order to maximise its impact and added value.

In order to achieve the aforementioned objectives, EU-Rail its activities via calls for proposals and for tenders. The 2022 Call for Proposals is structured in the following 6 Destinations and each of them is supposed to generate a Flagship Project²⁹:

1. **Destination – Network management planning and control & Mobility Management in a multimodal environment and Digital Enablers.** The objective is to achieve the Single European Rail Area by researching, developing and delivering a flexible, efficient, resilient and high-capacity European rail network. It also about the implementation of a railway Digital enabler and Digital twin environment, where all digital elements of the system can play together in a coherent and interoperable way.
2. **Destination - Digital & Automated up to Autonomous Train Operations.** The objective is to research, develop and deliver the next generation Automated Train Control system and scalable automation in train operations to optimize operations and increase capacity on the network.
3. **Destination – Intelligent & Integrated asset management.** The objective is to research, develop and deliver innovative solutions, including definition of technical requirements and standards, methods, and services –based on the latest leading-edge technologies and concepts to minimise asset life-cycle costs and/or extend life cycles while meeting safety targets and improving reliability, availability and capacity of the railway system, addressing both infrastructure and rolling stock.
4. **Destination – A sustainable and green rail system.** The objective is to research, develop and deliver innovative solutions and services based on leading edge technologies to minimize the overall energy and resource consumption and environmental impact of the railway system, to make this transportation mode healthier, more attractive and to provide resilience against climate change at a reduced total cost of ownership.
5. **Destination – Sustainable Competitive Digital Green Rail Freight Services.** The final objective is to make rail freight more attractive through digitalization and automation of operational functions and processes, including those at the intersection with other transport modes, as

²⁸ Directive 2016/797 of the European Parliament and of the Council of 11 May 2016 on the interoperability of the rail system within the European Union.

²⁹ In accordance with the Whereas 21 of the COUNCIL REGULATION (EU) 2021/2085, establishing Europe's Rail.

well as increasing the efficiency of the immaterial (information/data) layer of transport via researching, developing and delivering innovative interoperable and scalable solutions.

6. **Destination – Regional rail services/ Innovative rail services to revitalize capillary lines.** The final objective is to ensure long term viability of regional railways by decreasing the total cost of ownership (TCO), i.e. the cost per kilometer both in terms of OPEX and CAPEX, while offering a high quality of service and operational safety. In addition, the aspired results aim to increase customer satisfaction – including in relation to ticketing and related aspects - and to become an attractive and preferred choice of transport mode.

Topics	Type of Action	Budgets (EUR million)			Expected EU contribution per project (EUR million) ³⁰	Number of projects expected to be funded
		2021/2022	2023	2024		
	Opening: 10 March 2022 Deadline(s): 23 June 2022					
HORIZON-ER-JU-2022-FA1-TT-01	IA	22.0	12.0	4.0	38.0	1
HORIZON-ER-JU-2022-FA2-01	IA	31.5	17.0	5.8	54.3	1
HORIZON-ER-JU-2022-FA3-01	IA	26.9	14.5	4.9	46.3	1
HORIZON-ER-JU-2022-FA4-01	IA	22.2	12.0	4.1	38.3	1
HORIZON-ER-JU-2022-FA5-01	IA	23.5	12.8	4.3	40.6	1
HORIZON-ER-JU-2022-FA6-01	IA	9.6	5.2	1.7	16.5	1
Overall indicative budget		135.7	73.5	24.8	234.0	

³⁰ Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

1. DESTINATION 1 – Network management planning and control & Mobility Management in a multimodal environment and Digital Enablers

DESTINATION 1 – description (possibly included in the Expected Outcome in the Funding Portal)

In the context of Network management planning and control & Mobility Management in a multimodal environment, the objective is to research, develop and deliver the functional requirements, associated specifications, and operational and technological solutions to enable a common future European Traffic Management layer. This shall include the requirements to achieve uniform train operations; ticketing services may also be considered part of such endeavour. This will enable the design of future network and capacity management, planning, and control.

In order to accelerate the European approach, research and innovation in the Flagship Project stemming from this topic shall also consider early implementation of common functions and approaches starting from existing national TMS. A dynamic network and traffic management at European scale, built upon a harmonised functional system architecture to ensure agile, borderless and mixed-traffic operations, is the target solution that the various legacy TMS should migrate towards.

This extends the capacity planning at European level and enables the automatic management of cross-border rail traffic. Improved service offers, operations and capacity utilization are reducing the inefficiencies of the door-to door services and enhancing the competitiveness of rail-based mobility chains.

To achieve the overall objective of a dynamic European traffic management, several improvements have been identified and described in the Europe's Rail Multi-Annual Work Programme³¹.

When the railway system becomes fully digital and connected, the availability of real-time and historical data from across the whole system will unlock a whole range of new possibilities. However, a fully digital connected rail system will be characterized by a complex landscape comprising multiple heterogeneous systems and interactions.

For this reason, Destination 1 has also the objective to ensure the implementation of a railway Digital enabler and twin environment, where all digital elements of the system can play together in a coherent and interoperable way.

Proposals under this Destination should set out a credible pathway (including an exploitation plan) to contributing to all of the following expected impacts as described in the Master Plan.

The selected proposal for funding under this Destination will be a Flagship Project of Europe's Rail with significant expected impacts, which require an integrated sector systemic approach. Proposals should therefore set out a credible pathway (including an exploitation plan) to contributing to all of the following expected impacts as described in the Master Plan.

³¹ See MAWP (<https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>) chapter 7.1.1 and subchapters



Meeting evolving
customer
requirements



Improved EU rail
supply industry
competitiveness



Reinforced role
for rail in
European
transport and
mobility



Harmonised
approach to
evolution and
greater
adaptability



More sustainable
and resilient
transport

In the context of Network management planning and control & Mobility Management in a multimodal environment, proposals under this Destination should deliver the innovative solutions to be demonstrated and monitored to achieve the following levels by 2031:

Improved strategic and tactical planning of the rail network:

- Increased number of possible trains on a given infrastructure on a reference day using improved processes and methods:
 - Baseline 2022, expected increase 5% to 20%, depending on the line or area.
- Reduction of answering time between the short term request of a cross-border train path and the answer with an adequate offer:
 - Down to 5 minutes.
- Improved robustness of timetables and hence, reduced impact of disturbances and disruptions
 - Baseline 2022, expected decrease 5% to 15% of delay minutes in a reference week depending on the line or area

Develop resilience for a connected real-time network

- Prediction Quality as the basis for decision quality in Traffic Management: For a representative set of 100 trains running in a 2h interval ahead of actual time, less than 5 percent of the predicted timing shall not deviate from the actual more than 5 minutes. Note: Train cancellations not considered
- Prediction performance as the basis for in-time decision making in Traffic Management: less than 120 seconds in a typical set of 100 trains running in a 2h interval ahead of actual time. Note: Prediction shall consider dynamic infrastructure constraints (e.g., TSR, track blockages), implemented train control decisions and automated conflict resolution.
- ATO Journey Profile / Segment Profile provision cycle time down to 30 secs

Integrate rail traffic within door to door mobility

- Demand forecast for improved service planning:
 - Achieve 65% precision in the average forecast 1 week in advance
 - Achieve 80% precision in the forecast at 1 hour
- Improved matching between demand and supply:
 - Achieve 75% reaching passengers' planned travel time

In the context of Digital enablers and twin, the expected specific impacts of this Destination are:

- Improved EU rail supply industry competitiveness among others by reducing duration and costs for development and certification by several measures of digitalisation e.g. virtual certification tasks that can be conducted in a laboratory by 80%
- Number of Digital Twins able to be integrated, tested and validated in the “Design Environment”: achieve minimum 5 Digital Twins developed by Destinations integrated in the “Digital Twin transversal Environment”
- Improve the use of federated Data and CDM: achieve 10% increase of Number of shared entities federated (referred).

The following call(s) in this work programme contribute to this Destination:

Call	Budgets (EUR million)			Deadline
	2021/2022	2023	2024	
HORIZON-ER-JU-2022-01	22.0	12.0	4.0	23 June 2022
Minimum overall indicative budget	38.0			

Call: HORIZON-ER-JU-2022-01

Conditions for the Call

Indicative budget(s)

Topics	Type of Action	Budgets (EUR million)			Expected EU contribution per project (EUR million) ³²	Number of projects expected to be funded
		2021/2022	2023	2024		
	Opening: 10 March 2022 Deadline(s): 23 June 2022					
HORIZON-ER-JU-2022-FA1-TT-01	IA	22.0	12.0	4.0	38.0	1
Overall indicative budget		38.0				

³² Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

General conditions relating to this call	
<i>Admissibility conditions</i>	The conditions are described in part A of the General Annexes to the Horizon Europe Work Programme 2021-2022
<i>Eligibility conditions</i>	The conditions are described in part B of the General Annexes to the Horizon Europe Work Programme 2021-2022
<i>Financial and operational capacity and exclusion</i>	The criteria are described in part C of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Award criteria</i>	The criteria are described in part D of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Documents</i>	The documents are described in part E of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Procedure</i>	The procedure is described in part F of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Legal and financial set-up of the Grant Agreements</i>	The rules are described in part G of the General Annexes to the Horizon Europe Work Programme 2021-2022.

Proposals are invited against the following topic(s):

HORIZON-ER-JU-2022-FA1-TT-01: Network management planning and control & Mobility Management in a multimodal environment and Digital Enablers

Specific Conditions	
Expected EU contribution per project	EU-Rail estimates that an EU contribution of EUR 38.0 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	<p>The total indicative budget for the topic is EUR 38.0 million.</p> <p>Applicant Private³³ Members of the EU-Rail JU part of consortia responding to this topic should provide in-kind contributions to additional activities to be declared via the template model available on the F&T portal. The amount of total in-kind contributions (i.e. in-kind contributions for operational activities and in-kind contributions for additional activities) should be no less than 1.263³⁴ times the funding request, in aggregate, of these applicant Private Members. Any discrepancy shall be well and duly justified.</p>

³³ As defined in Article 2(5) of Council Regulation (EU) 2021/2085.

³⁴ In order to support a leverage factor of no less than the ratio between the contribution from members other than the Union and the Union financial contribution, as on the basis of Articles 88 and 89 of Council Regulation (EU) 2021/2085.

Specific Conditions	
	In this respect, the grant agreements will set, in principle, annual deliverable on in-kind contributions for the projects selected under this topic, as well as mandatory reporting requirements, for those applicants who are Private Members of the EU-Rail JU.
Indicative project duration	48 months.
Type of Action	Innovation Action
Technology Readiness Level	Activities are expected to achieve a minimum between TRL 5 and TRL 7, depending on the enabler addressed, or higher by the end of the project – see General Annex B for a guide to the TRL definitions and criteria to be used.
Admissibility conditions	Regarding admissibility conditions and related requirements, part A of the Horizon Europe Work Programme 2021-2022 General Annexes applies with the following exception: the limit for a full Innovation Action application is set to 120 pages.
Special skills and/or capabilities expected from the Applicant(s)	<p>Applicants shall ensure that their proposals and consortium reflect the aggregated expertise to perform the activities and achieve the objectives set by the Destination:</p> <ul style="list-style-type: none"> • Expertise from rail infrastructure managers and railway undertakings, which should allow <ul style="list-style-type: none"> – defining main challenges, use cases and functional needs, – specifying, prioritizing and clustering demonstrators to ensure that researched innovative processes, operational and technological solutions are covered, – hosting the demonstrations and providing test trains/facilities, – providing data structures and content as well as processes, e.g. certification which can be subject for digitalisation. • Expertise from rail suppliers (system integrators, manufacturers and/or technology providers), which should allow, jointly, <ul style="list-style-type: none"> – proposing operational and technological innovative solutions to identified use cases and functional needs, – identifying the technical requirements and interface specifications, aligned with the System Pillar architecture, – designing, developing, prototyping and delivering innovative operational & technological solutions and systems to be integrated within the demonstrations, depending on the specific target TRL level. • Expertise from research institutes and academia, which should allow <ul style="list-style-type: none"> – planning, developing, studying, testing and evaluating solutions, systems and demonstrators together with the previous categories of expertise, – supporting any possible scientific or methodological issues that may arise during the performance of the action – contributing to other aspects of the innovation cycle, as well as to the procedural aspects for validation, certification, etc.

Specific Conditions	
	<ul style="list-style-type: none"> Complementary expertise from other sectors and parties, with particular attention to SMEs and Start-ups, which may contribute to enhance the actions' outcome.
Contribution to the monitoring and implementation, standardisation, of the EU-Rail Programme	<p>The action resulting from this topic is identified as a “flagship project” expected to perform, by the completion of the research and innovation lifecycle, “large scale demonstrations”, in the meaning of Council Regulation (EU) 2021/2085. Hence, the action is a key contributor to the achievement of the objectives identified in the Master Plan³⁵ as further detailed in the Multi-Annual Work Programme³⁶.</p> <p>In this respect, applicants are expected to deliver relevant information (data, results, etc.) as mutually agreed, to the JU and the Linked Project[s] to contribute to the advancement of the Innovation and System Pillars³⁷ activities, as well as in view of the development and implementation of EU policy and legislation (including Technical Specifications for Interoperability and Common Safety Methods) and the development of European standards. As specified in section 2.3.3.2 of the AWP 2022, and to facilitate contributions to European or international standards, the EU-Rail grant agreements will include an additional information obligation related to standards. Beneficiaries must inform the EU-Rail JU (up to four years after the end of the action) if the results can be reasonably expected to contribute to European or international standards.</p> <p>As part of its internal control and management framework, the JU will perform a of reviews and maturity checkpoints to assess the overall progress against the project plan and against the performance and TRL targets. Depending on the outcome of these reviews and maturity checkpoints(s), the scope of the project may be revised and/or funding reduced in accordance with the provisions of the relevant grant agreement. Mitigation actions may be requested by the JU as condition for continued funding.</p> <p>The proposal shall consider the necessary resources – FTE and/or other – to ensure the monitoring of the “Flagship Project” via regular reporting, reporting of data for the Programme KPIs, etc.. A EU-Rail Governance and Process Handbook is available here : https://shift2rail.org/participate/</p>
Linked Projects	<p>As specified in section 2.3.3.2 of the AWP 2022, in order to facilitate the contribution to the achievement of the EU-Rail JU objectives, the options regarding 'linked actions' of the EU-Rail Model Grant Agreement and the provisions therein, is enabled in the corresponding EU-Rail JU Grant Agreements.</p> <p>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:</p> <ul style="list-style-type: none"> HORIZON-ER-JU -2022-FA2-01: Digital & Automatic up to Automated Train Operations

³⁵ Master Plan available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>.

³⁶ MAWP available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>.

³⁷ Refer to the Multi-Annual Work Programme available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

Specific Conditions	
	<ul style="list-style-type: none"> • HORIZON-ER-JU -2022-FA3-01: Intelligent & Integrated asset management • HORIZON-ER-JU -2022-FA4-01: A sustainable and green rail system • HORIZON-ER-JU -2022-FA5-01: Sustainable Competitive Digital Green Rail Freight Services • HORIZON-ER-JU -2022-FA6-01: Regional rail services / Innovative rail services to revitalise capillary lines <p>Please note that the list non-exhaustive as additional Linked Projects may follow at a later stage of the programme implementation to complement the activity.</p>
Funding of only one project per topic	EU-Rail JU may award up to one project with funding depending on the outcome of the evaluation and the complementarity of the proposed actions.
Retroactive starting date of the grant	The starting date of grants awarded under this topic may be as of the submission date of the application. Applicants must justify the need for a retroactive starting date in their application. Costs incurred from the starting date of the action may be considered eligible.
Lump Sum grant	Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025). [[This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under ‘Simplified costs decisions’ or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lump-sum-decision_he_en.pdf]].
Lower funding rate	The funding rate of the action is 60% of the eligible costs to achieve the leverage effect established in the SBA. Each Consortia may decide internally different funding rates in line with the provisions of Article 34 of Horizon Europe nevertheless complying with the overall funding rate of 60%.
Award criteria additional details	The award criteria included in the General Annexes of the Horizon Europe – Work Programme 2021 – 2022 are complemented with additional criteria as specified in Annexe 8 this Work Programme.
Additional dissemination obligations	In addition, as specified in section 2.3.3.2 of the AWP 2022, and to facilitate contributions to considering the key contributing role of this topic, in designing the dissemination and communication activities, the proposal shall consider that the “Flagship Project” will be part of the overall EU-Rail Programme and the planning of key events – demonstrations, participations to fair, etc. – will be coordinated at Programme level and by the “Stakeholder Relations and Dissemination” structure of the JU.

Expected Outcome:

The action to be funded under this Destination shall address two work streams (WS):

WS1: Network management planning and control & Mobility Management in a multimodal environment

The developed solutions shall enhance capabilities and allow to achieve the following outcomes:

Improved strategic and tactical planning of the rail network:

The innovative functionalities of planning & simulation³⁸ shall enable automation in decision support systems (e.g. for supporting the management of short term path requests), conflict resolution, deployment of resources such as network, crew, rolling stock and energy, thus boosting the efficiency of the rail network and its operations, considering as well international strategic planning initiatives by the sector³⁹. Coherence with external services and operational technologies for future planning processes shall be ensured by taking into account for example the related driving modes and onboard technologies such as C-DAS or ATO⁴⁰ already at the planning stage. This specifically should address the areas of cross-border planning, yard and station processes, traffic management and ETCS or ATO modelling. The innovations shall be integrated/connected and used with state-of-the-art systems, to demonstrate the intended functionalities and the capability to be implemented for production use.

Increased resilience of a connected 'real time' rail network:

Another output of the activities carried out in this Destination shall be the European real-time railway traffic management and operations with the goal to provide a more agile, optimized and automated response to unplanned situations, such as disturbances and responses to dynamic demand especially in cross-border traffic situations. Such significantly enhance TMS⁴¹ shall be capable to support interoperable traffic management on a European dimension, which shall increase the resilience of a connected "real-time" rail network in Europe. The solution should ensure optimisation of the quality of cross-border train paths in the scheduling process (e.g. resource negotiation with subsystems), as well as the corresponding real-time deviation management. An optimized overall system architecture and operational workflows have to be developed together with the System Pillar.

³⁸ Results from Shift2Rail activities should be taken into account, see PLASA-2 project (https://projects.shift2rail.org/s2r_ipcc_n.aspx?p=plasa-2) : D2.1 Smart planning - feasibility study, D2.2 Smart planning – summary of methods dealing with incomplete data, D 3.4 Case study on resource dependencies, FR8Rail-2 (https://projects.shift2rail.org/s2r_ip5_n.aspx?p=FR8RAIL%20ii) D3.2 Demonstrators of intelligent planning modules trains and infrastructure possession planning, combined modules simulation and optimisation.

³⁹ E.g. taking into account initiatives such as Eurolink

⁴⁰ Results from Shift2Rail activities should be taken into account, see FR8RAIL II (https://projects.shift2rail.org/s2r_ip5_n.aspx?p=FR8RAIL%20ii) D4.4 Evaluation of C-DAS demonstration, and X2RAIL-4 (https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-4) D3.1 and D3.2

⁴¹ Results from Shift2Rail activities should be taken into account, see OPTIMA (https://projects.shift2rail.org/s2r_ip2_n.aspx?p=S2R_OPTIMA) D4.1 Design document and X2Rail-2 (https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-2) D6.1 SYSTEM REQUIREMENT SPECIFICATION (SRS) FOR THE INTEGRATION LAYER

The solution should develop and integrate a number of enablers for an improved real-time door-to-door offer planning and management. It includes better information exchange between operators (for operational issues), long-term and short-term demand predictions for all parts and stretches of the chain, and systems for dynamic best offers (incl. real-time availability of resources and network constraints). To enable the developed technologies to be put in effective use, in parallel to technological developments, there shall be a process defined between European IMs, RUs and other relevant actors to agree on necessary data management and data exchange. Additional enablers are improved accessibility and attractiveness at the interconnection, specifically for Persons with Reduced Mobility (PRM).

The Flagship Project stemming from this topic shall deliver by 2025 innovative solutions to be demonstrated with:

- Tactical and short-term timetable planning including cross-borders with improved models and functions; use of decision support to support integrated capacity planning of the rail network and operations for yards, stations, terminals [TRL6/7]
- HMI for TMS with decision support modules, based on User Experience (UX) Design and human-in-the-loop awareness [up to TRL6-8]
- Demand-driven predictions to improve operations and service offers, considering information about events across modes. Effect of cross-regional, multimodal travels in combination with demand forecast and disruption handling on improvement of daily operations, benefit on customers (accessibility and attractiveness). [TRL 7-8]:

In addition of the above, the proposal shall cover important preparatory works needed to be launched for the future set of demonstration foreseen in the Multi-annual Work programme in view of the evolutions of the solutions:

- Functional system for strategic, tactical and short-term planning considering ERTMS and ATO involvement and their related effects on capacity [
- Planning using integrated feedback loops from operations, including TMS and C-DAS/ATO
- Using ATO journey profiles for timetabling
- (1) *TMS at regional area* with decision support and interaction between actors, including integration with incident management and handling of maintenance, co-operative planning for improved interaction between nodes (important yards and stations) and rail network as well as cross-border operations and asset conditions for rolling stock and infrastructure in real-time [
- (2) *TMS at global area* : decision support and automation and overall real-time traffic plan, with feedback loops from operation to planning, showcasing the capabilities:
 - Real-time connection of the networks
 - Improved modelling for cross-border
 - Integration of energy management⁴² (Electric Traction System)
 - Real-time crew / rolling stock dispatching
 - Cooperative planning multi-actors
 - Dispatching, incident management and customer information
 - Disruption management

⁴² Results from Shift2Rail activities should be taken into account, see In2Rail project (<http://www.in2rail.eu/>) D10.4 TMS/MMS Interface Specification

- Increased automation in decision support
- Conflict detection & resolution
- Improved long-term demand driven predictions considering short term demand forecast and disruption management and using additional data sources and external data (e.g., public events, seat availabilities).
- Use of Digital Twins for the visualisations and modelling of movements at train stations
- Cross-border travel within Europe and the connection of rural areas to create an inclusive mobility network, with focus on PRM guidance based on real-time data

The action to be funded under this Destination also needs to provide the following necessary element for the demonstrations under the action to be funded under *Digital and Automated, up-to Autonomous train operations* (Destination 2) to be delivered for 2025 demonstrations: TMS functionality for serving autonomous path allocation [TRL5]

The action to be funded under this Destination also needs to provide the following necessary elements for the demonstrations under the action to be funded under the Destination *Sustainable Competitive Digital Green Rail Freight Services* (Destination 5) to be delivered for 2025 demonstrations: enablers 1, 2, 3, 4, 6a, 9, 10a, 10b, 10c and 10d as described under the Scope section of this Destination. In addition to the above, the proposal shall cover important preparatory works needed to be launched for the future set of FA5 demonstration foreseen in the Multi-annual Work programme in view of the evolutions of the solutions, linked with those same enablers at higher TRL.

The action to be funded under this Destination also needs to provide the following necessary elements for the demonstrations under the action to be funded under the Destination *Regional rail services / Innovative rail services to revitalise capillary lines* to be delivered for 2025 demonstrations: enablers 1, 3, 4, 5, 13, 14, 15, 17, 18, 19, 23 and 27 as described under the Scope section of this Destination. In addition of the above, the proposal shall cover important preparatory works that needs to be launched for the future set of FA6 demonstrations foreseen in the Multi- annual Work programme in view of the evolutions of the solutions, linked with those same enablers at higher TRL.

WS2: Digital Enablers

By definition a Digital Twin is a virtual representation able to imitate the behaviour of a physical system during the spans of its lifecycle. Within the railway, a Digital Twin encompass at least two levels, a Unit level (Functional Mock-up Units- FMU) where specialized “domain-knowledge” is located and a Interface level (Functional Mock-up Interfaces - FMI) where I/O requirements as well as the interactions among FMU are implemented.

The work stream on digitalisation should support operational processes and activities of all Destinations and especially the implementation of the related use cases. It will take into account the System Pillar (SP) CONOPS (Concept of Operation) of the rail system as well as definitions of SP-architectures and SP-interfaces. Requirements, implementation and data for the Digital Twins are responsibility of this Destination. This workstream will support this by three aspects:

- “Digital Twin Support Environment” for operational processes of the Destinations by composition of reusable, black-boxed, compiled, digital interoperable model units (FMU) of components, subsystems and super-systems.

- “Digital Twins Design Environment” to facilitate the integration at interface level (FMI) as well as validation, verification, and test, including model registry and discovery services and interoperability validation tools
- A “Run-Time Environment” based on a Federated dataspace to feed and execute Digital Twins to ensure a common Ontology and associated Federation Services such as: Identity and Trust management, Data Assets registry and discovery services, Data Distribution Services, Data stream management, Cyber security etc.

Digital Enablers’ Architecture and related interfaces need to be wider than the Architecture provided e.g. for the CCS+ to enable the Digital Twin environment to work properly. Hence the results and definition of the SP need to be taken into account and represented.

Rapid development of digital technologies offers numerous opportunities for creating new value-added services in the railway industry. To seize these opportunities, the following outcomes must be achieved by this WS:

- 1) Develop data federation, access and processing services through standardized interfaces
- 2) Based on the outputs and toolset developed within LinX4Rail⁴³, a common machine-readable domain ontology must be developed to structure the data unambiguously across all systems participating in data sharing
- 3) Ensure a powerful, secure and reliable data and communication infrastructure.

The railway digital enabler is meant to be considered as a set of concepts, models, technologies and methods addressing the three levels of actions - data, services and digital infrastructure. The railway digital enabler is therefore a framework that needs to be filled with real technology and architectures in specific Destinations applications. Related to this concept, it should be emphasized that in addition to a common standardized / well-documented data space, a common standardized / well-documented semantics and standardized / well-documented protocols are also needed and shall be worked out in detail.

All the expected output of the action to be funded under this WS shall be exploited by all Destinations in building and executing Digital Twins.

In addition, this WS shall include preparation work:

- for modular built-up of Digital Twin within the development environment
- use of artificial intelligence to collect and analyse data patterns and support decision making process
- real time algorithms using Digital Twins

Scope

Action to be funded under this topic should research, develop, and deliver the following capabilities and/or any other relevant capability to achieve the aforementioned expected outcome:

WS1:

⁴³ Results from Shift2Rail activities should be taken into account, see LinX4Rail project (https://projects.shift2rail.org/s2r_ipx_n.aspx?p=LINX4RAIL) D2.3 Final version of the dictionary

To improve strategic and tactical planning of the rail network developing solutions that enable by 2025:

Enabler 1: European cross-border scheduling with international train path planning [TRL6/7]

Enabler 2: Improved capacity allocation using rolling planning and TTR [TRL6/7]

Enabler 3: Decision support for short term planning [TRL5/6]

Enabler 4: Train path and schedule optimization methods and strategies for capacity efficiency, punctuality and energy saving for different parts of the network and different traffic situations (level of punctuality). [TRL5/6]

Enabler 5: Improved rail traffic simulation models for selected Use Cases to forecast punctuality in the network (e.g. simulating proportion primary and secondary delays, simulations drivers vs. ATO over ETCS ...) ⁴⁴. [TRL6/7]

Enabler 6: Integration of TMS with a) yard capacity planning and b) station capacity planning [TRL5/6]

Enabler 7: New planning and operational processes using feedback loops from ERTMS ATO and C-DAS [TRL5/6]

Developments on all those enablers should also cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions.

To increase resilience of a connected 'real time' rail network developing solutions that enable by 2025:

Enabler 8: Real-time connection of rail networks as managed by TMSs and involved actors [TRL6/7]

Enabler 9: Modelling and decision support for cross-border traffic management [TRL5/6]

Enabler 10: Integration of TMS with a) yard management system and processes; b) station management system and processes; c) energy management (Electric Traction System); d) real-time crew / rolling stock dispatching [TRL6/7]

Enabler 11: HMI for TMS based on User Experience (UX) Design and user input [TRL8]

Enabler12: Real-time convergence between planning & feedback loop from operations [TRL4/5]

Enabler 13: Cooperative planning multi-actors within rail [TRL4/5]

Enabler 14: Integration of incident management and customer information, with IM and RU interaction and Decision Support for Disruption management [TRL4/5]

Enabler 15: TMS speed regulation of trains, precise routes and target times for ATO and dynamic timetables [TRL4/5]

Enabler 16: Automation of very short term ⁴⁵ train control decisions [TRL5]

⁴⁴ Results from Shift2Rail activities should be taken into account, see PLASA-2 (https://projects.shift2rail.org/s2r_ipcc_n.aspx?p=plasa-2) D3.4 Smart planning: Approaches for simulation with incomplete data and FR8Rail II (https://projects.shift2rail.org/s2r_ip5_n.aspx?p=FR8RAIL%20ii) D3.4 Demonstrator on Improved Planning Verification of Demonstrators

⁴⁵ time ahead of 0 in which a train controller cannot implement control decisions manually; usually a couple of minutes

Enabler 17: Real-time conflict detection & resolution⁴⁶ for main line and optimisation [TRL4/5]

Developments on all those enablers should also cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions.

To integrate rail traffic within door-to-door mobility developing solutions that enable by 2025:

Enabler 18: Improved rail integration using B2B intermodal services: cross-operator information sharing on e.g. sales and distribution, traffic information, end-user experience, ... [TRL6/7]

Enabler 19: Harmonized interfaces between rail operators and other transport modes, leveraging existing European standards when applicable to enhance collaboration between mobility providers and support B2B integration including the objective to deliver an enhanced end-user experience [TRL7/8]

Enabler 20: PRM information sharing between rail operators and other transport modes (e.g. information on connections) for assistive digital tools⁴⁷. [TRL4/5]

Enabler 21: Hands free solutions for travellers using rail services and transferring between operators and mobility modes leveraging newest technologies (e.g. WiFi roaming, Bluetooth Low Energy (BLE), Ultra Wide Band (UWB), 5G, Face recognition...)⁴⁸. [TRL7/8]

Enabler 22: Innovative platform-based passenger guidance solution, measurement and guidance of customer flows to and on the platform [TRL4/5]

Enabler 23: Short term demand forecast calculation using run time data (e.g. ticketing data, short term weather forecast, passenger density,) [TRL6/7]

Enabler 24: Long term demand forecast with focus on data analytics based on a variety of sources (e.g., public events, holiday calendar) and operators' data (e.g., fare, passenger density data) and historical information for predictive models related to passenger clustering⁴⁹ [TRL4/5]

Enabler 25: Integrated traffic simulation and demand forecast in a Digital Twin to optimize offer, passenger occupancy, connection time and other service-related elements [TRL4/5]

Enabler 26: Optimized rail capacity to better match the demand: Synergy between short term and long term forecast (e.g. weather forecast for an airport line) combined with Digital Twins in order to provide optimization guidance [TRL4/5]

Enabler 27: Disruption management across different mobility modes enabling operators to collaboratively solve the disruption and properly inform passengers [TRL6/7]

⁴⁶ Results from Shift2Rail activities should be taken into account, see X2Rail-4 (https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-4) D8.1 Functional Specification of Processes

⁴⁷ For reference, past S3R activities are linked to TD4.5 https://projects.shift2rail.org/s2r_ip_TD_r.aspx?ip=4&td=5f96fb11-4686-474e-a403-abf50108fb0d

⁴⁸ For reference, past S3R activities are linked to TD4.5 https://projects.shift2rail.org/s2r_ip_TD_r.aspx?ip=4&td=5f96fb11-4686-474e-a403-abf50108fb0d

⁴⁹ For reference, past S3R activities are linked to .6 https://projects.shift2rail.org/s2r_ip_TD_r.aspx?ip=4&td=fe8a122e-657a-4a8b-b44a-e7a269c7e491

Developments on all those enablers should also cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions.

In addition to the capabilities and enables listed above, Cyber protection of systems and data also needs to be provided.

WS2:

Connectors for Federated Data Spaces, TRL6 by 2025

A need for *federated data spaces* to make all heterogeneous data available to specialized digital applications in multiple domains while a) allowing incremental extensions and avoiding the rigidity of synchronized and centralized deployment timelines and b) providing data owners with the ability to retain control of their assets.

A federated data space is a distributed secure and reliable data sharing and communication infrastructure enabling data federation, access and processing services through standardized interfaces. Incremental extensions of the federated data space are achieved by new devices and systems using the exposed services to add themselves to the federation as they become available, while data asset protection by their owners is achieved by each participant implementing their own data access policies at the interface between their system and the federated dataspace. Connectors using these interfaces must be developed for existing or legacy/proprietary systems to participate in the federation. The sequence of successive federations must take into account the dependencies identified in Annex B between Destinations.

Common Domain Ontology, building upon S2R works on Conceptual Data Model (CDM), TRL 6 by 2025

High quality data and its accessibility is key to the success of the next generation of railway application and services. Therefore, data does not only need to be of high semantic quality, but also has to be specified by a standardized high quality syntax. Not only shall the underlying concepts and principles of the CDM be respected, but they shall also take advantage of the work produced in LinX4Rail⁵⁰ and further develop the coverage, add additional value and to make use of it using fully interoperable Digital Twins in syntax and semantics. Based on the alignment with other Destinations.

Digital Twin support, development and execution environment, TRL5 by 2025

As a virtual representation able to imitate the behaviour of a physical system, a Digital Twin is a software implementation of a structural and behavioural model of the represented system. A development environment for Digital Twins shall be composed of standard modelling tools, editors, compilers and debuggers used by specialists to create self-contained, compiled functional mock-up units (FMUs). Searchable libraries of FMUs are also part of the Digital Twin development environment, used to implement higher level FMUs as compositions of submodels through standardized interfaces.

⁵⁰ Results from Shift2Rail activities should be taken into account, see LinX4Rail project (https://projects.shift2rail.org/s2r_ipx_n.aspx?p=LINX4RAIL) D2.3 Final version of the dictionary

Compiled FMUs are deployed to an interoperable Digital Twin execution environment in which models are initialized with data obtained from the federated dataspace through the dataspace services, and simulations runs are performed to generate the projected behaviour of the imitated physical system.

The action shall actively contribute to measure and monitor the specific quantitative KPIs defined in the Destination description above, including its contribution to the Europe's Rail Master Plan impacts.

The action shall actively contribute to the EU-Rail standardisation rolling development plans wherever relevant. Similarly, the action shall contribute to the development and implementation of EU policy and legislation including Technical Specifications for Interoperability and Common Safety Methods, as well as to publications of the System Pillar.

Collaboration work required with other Destinations

The required collaboration work with other Destinations should foresee the following in order to ensure consistency on expectations and a coordinated implantation:

- Developing deliverable(s) capturing specific requirements and delivery schedules described in the Expected scope and relevant for the action to be funded under Destination 2, Destination 3, Destination 4, Destination 5 and Destination 6, suggested to be delivered indicatively by M6.
- Common activities/tasks related to the review of system specifications to be developed by the action to be funded under Destination 2, Destination 3, Destination 4, Destination 5 and Destination 6.
- For WS1 only, a common activity/task related to the Preparatory works on the integration and pilot test(s) of the technical enablers to be provided by the actions to be funded under Destination 2, Destination 3 and Destination 4 and Destination 5 for the demonstration to be carried out in the action to be funded by Destination 1, Destination 2, Destination 3, Destination 4, Destination 5 and Destination 6.

Interaction with the System Pillar

The System Pillar aims to guide, support and secure the work of the Innovation Pillar (i.e. to ensure that research is targeted on commonly agreed and shared customer requirements and operational needs, compatible and aligned to the system architecture), and the Innovation Pillar will impact the scope of the System Pillar where new technologies or processes mean that innovations can drive a change in approach, as well as delivering detailed specifications and requirements.

In this respect, the proposal should allocate necessary resources that would be dedicated to areas linked to the System Pillar conceptual and architecture works – particularly addressing specification development (the interaction is illustrated in the System Pillar – Innovation Pillar interaction note (Annex VI of this Work Programme). The alignment of the activities will primarily take place during the Grant Preparation Phase and ramp up phase of the awarded proposal, and there will be continued, structured and regular interaction through the life of the project.

Gender dimension In this topic the integration of the gender dimension (sex and gender analysis) in research and innovation content is not a mandatory requirement.

2. DESTINATION 2 – Digital & Automated up to Autonomous Train Operations

DESTINATION 2 – description (possibly included in the Expected Outcome in the Funding Portal)

Today, urbanisation and population growth are already leading to rail capacity problems on main lines across Europe. To increase the railway capacity there are two main options: building new infrastructure and/or operating the rail system in a way that takes advantage of new technological and operational solutions. A major opportunity is offered by digitalization and automation of rail operation, where DATO (Digital “Automated” Train Operations) represents the most visible result of a major transformation of rail operations, which builds upon a next generation of Automatic Train Control (ATC), in addition to enhancements on the Train Control and Monitoring System (TCMS) allowing for integration at the on-board level. ATC⁵¹ is the combination of Automatic Train Protection (ATP) systems, Automatic Train Supervision (ATS), and Automated Train Operation (ATO) – together representing an evolution of the current Control, Command and Signalling (CCS) subsystem –termed CCS+.

The aim of this destination is to take the major opportunity offered by digitalization and automation of rail operation and to develop the Next Generation ATC and deliver scalable automation in train operations, up to GoA4.

The selected proposal for funding under this Destination will be a Flagship Project of Europe’s Rail with significant expected impacts, which require an integrated sector systemic approach. Proposals, should therefore set out a credible pathway (including an exploitation plan) to contributing to all of the following expected impacts as described in the Master Plan.



Meeting
evolving
customer
requirements



Reduced costs



Harmonised
approach to
evolution and
greater
adaptability



Improved EU
rail supply
industry
competitive-
ness



Improved
performance
and capacity



Reinforced
role for rail in
European
transport and
mobility

These can be further detailed with specific impacts of this destination, as:

⁵¹ The ATS is responsible for “[the] supervision of [the] train status, automatic routing selection, automatic schedule creation, automatic operations logging, statistics and report generation, and automatic system status monitoring”. The ATP system is designed as a fail-safe system, intended to keep a safe distance between trains and to make each individual train comply with the track speed limits. If the speed limit is exceeded, ATP will automatically slow down the train or even bring it to a complete stop. ATO is responsible for the train operation part, so the traction and braking controls, but also creating the trains speed profile, the communication with the wayside equipment, the opening and closing of the train doors, and automatic train reversal.

- Lowering expenses of railway undertakings and infrastructure managers,
- Decreasing travelling times for passengers and freight,
- Increasing the overall capacity of the rail operation,
- Increasing the punctuality,
- Improving the quality of operation,
- Increasing operational reliability,
- Improving recovery time after any interruption or intervention,
- Improving reaction time,
- Increasing flexibility in planning on existing infrastructure,
- Reducing energy consumption.

Proposals under this Destination should set appropriate monitoring and demonstration activities to measure the following KPIs:

Type of impact	KPI	Expected Improvements
A first technical KPI which can show the improved flexibility in the responsiveness is the system response time which could be given based on the reaction requested from FA1.	Responsiveness is understood as the time to react to a request from FA1 in a shorter time than today. Responsiveness provided by FA2 is the enabler for improved flexibility and can be measured as time.	Reduction from 2h to 2Min.
The accidentology indicator will show the improvement of the operational safety for mixed traffic in urban environment with trams while reducing the human factor in the normal operation.	No. of collisions with third-parties per 10.000 km travelled	Decrease by 50% (ca. from 0.2 to 0.1)
As operational KPI the improvement of the capacity can be used, as the increase as well indirectly improves travelling times, punctuality, quality of operation and reliability.	No. of trains on line per hour and direction	Increase of 10%
The cost-related operational KPI is the reduction of the Life-Cycle Cost (LCC) where especially the cost of operation includes energy consumption and productivity. CAPEX are assumed not to increase compared to today's, while including additional functionalities. OPEX-relevant factors reduced by different measures as e.g. productivity increased by higher automation in train operations, energy consumption reduction and improved punctuality by automation.	Energy consumption in kWh reduction measured as energy per passenger-km	Reduction by 10% compared to driver's average,
	Increased Staff productivity is understood as raising the productive hours, which are understood as worked hours from staff minus waiting times, commuting/shuttling times, etc.	Increase by 30%

Type of impact	KPI	Expected Improvements
	Punctuality is understood here as reduction in cumulated delay time and measured as delay/service in time	Reduction by 20%

The following call in this work programme contribute to this Destination:

Call	Budgets (EUR million)			Deadline
	2021/2022	2023	2024	
HORIZON-ER-JU-2022-01	31.5	17.0	5.8	23 June 2022
Minimum overall indicative budget	54.3			

Call: HORIZON-ER-JU-2022-01

Conditions for the Call

Indicative budget(s)

Topics	Type of Action	Budgets (EUR million)			Expected EU contribution per project (EUR million) ⁵²	Number of projects expected to be funded
		2021/2022	2023	2024		
	Opening: 10 March 2022 Deadline: 23 June 2022					
HORIZON-ER-JU-2022-FA2-01	IA	31.5	17.0	5.8	54.3	1
Overall indicative budget		54.3				

General conditions relating to this call	
<i>Admissibility conditions</i>	The conditions are described in part A of the General Annexes to the Horizon Europe Work Programme 2021-2022
<i>Eligibility conditions</i>	The conditions are described in part B of the General Annexes to the Horizon Europe Work Programme 2021-2022

⁵² Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

<i>Financial and operational capacity and exclusion</i>	The criteria are described in part C of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Award criteria</i>	The criteria are described in part D of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Documents</i>	The documents are described in part E of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Procedure</i>	The procedure is described in part F of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Legal and financial set-up of the Grant Agreements</i>	The rules are described in part G of the General Annexes to the Horizon Europe Work Programme 2021-2022.

Proposals are invited against the following topic(s):

HORIZON-ER-JU-FA2-01: Digital & Automatic up to Automated Train Operations

Specific Conditions		
Expected EU contribution per project	EU-Rail estimates that an EU contribution of EUR 54.3 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.	
Indicative budget	<p>The total indicative budget for the topic is EUR 54.3 million.</p> <p>Applicant Private⁵³ Members of the EU-Rail JU part of consortia responding to this topic should provide in-kind contributions to additional activities to be declared via the template model available on the F&T portal. The amount of total in-kind contributions (i.e. in-kind contributions for operational activities and in-kind contributions for additional activities) should be no less than 1.263⁵⁴ times the funding request, in aggregate, of these applicant Private Members. Any discrepancy shall be well and duly justified.</p> <p>In this respect, the grant agreements will set, in principle, annual deliverable on in-kind contributions for the projects selected under this topic, as well as mandatory reporting requirements, for those applicants who are Private Members of the EU-Rail JU.</p>	
Indicative project duration	48 months.	
Type of Action	Innovation Action	

⁵³ As defined in Article 2(5) of Council Regulation (EU) 2021/2085.

⁵⁴ In order to support a leverage factor of no less than the ratio between the contribution from members other than the Union and the Union financial contribution, as on the basis of Articles 88 and 89 of Council Regulation (EU) 2021/2085.

Technology Readiness Level	Activities are expected to achieve a minimum between TRL 5 and TRL 7, depending on the enabler addressed, or higher by the end of the project – see General Annex B for a guide to the TRL definitions and criteria to be used.
Admissibility conditions	Regarding admissibility conditions and related requirements, part A of the Horizon Europe Work Programme 2021-2022 General Annexes applies with the following exception: the limit for a full Innovation Action application is set to 120 pages.
Special skills and/or capabilities expected from the Applicant(s)	<p>Applicants shall ensure that their proposals and consortium reflect the aggregated expertise to perform the activities and achieve the objectives set by the Destination:</p> <ul style="list-style-type: none"> • Expertise from rail infrastructure managers and railway undertakings, which should allow <ul style="list-style-type: none"> – defining main challenges, use cases and functional needs, – specifying, prioritizing and clustering demonstrators to ensure that researched innovative processes, operational and technological solutions are covered, – hosting the demonstrations and providing test trains/facilities, – providing data structures and content as well as processes, e.g. certification which can be subject for digitalisation. • Expertise from rail suppliers (system integrators, manufacturers and/or technology providers), which should allow, jointly, <ul style="list-style-type: none"> – proposing operational and technological innovative solutions to identified use cases and functional needs, – identifying the technical requirements and interface specifications, aligned with the System Pillar architecture, – designing, developing, prototyping and delivering innovative operational & technological solutions and systems to be integrated within the demonstrations, depending on the specific target TRL level. • Expertise from research institutes and academia, which should allow <ul style="list-style-type: none"> – planning, developing, studying, testing and evaluating solutions, systems and demonstrators together with the previous categories of expertise, – supporting any possible scientific or methodological issues that may arise during the performance of the action – contributing to other aspects of the innovation cycle, as well as to the procedural aspects for validation, certification, etc. • Complementary expertise from other sectors and parties, with particular attention to SMEs and Start-ups, which may contribute to enhance the actions' outcome.
Contribution to the monitoring and implementation, standardisation of	The action resulting from this topic is identified as a “flagship project” expected to perform, by the completion of the research and innovation lifecycle, “large scale demonstrations”, in the meaning of Council Regulation (EU) 2021/2085. Hence, the action is a key contributor to the achievement of the objectives identified in the Master Plan ⁵⁵ as further detailed in the Multi-Annual Work Programme ⁵⁶ .

⁵⁵ Master Plan available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/Idem>

⁵⁶ MAWP available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

the EU-Rail Programme	<p>In this respect, applicants are expected to deliver relevant information (data, results, etc.) as mutually agreed, to the JU and the Linked Project[s] to contribute to the advancement of the Innovation and System Pillars⁵⁷ activities, as well as in view of the development and implementation of EU policy and legislation (including Technical Specifications for Interoperability and Common Safety Methods) and the development of European standards. As specified in section 2.3.3.2 of the AWP 2022, and to facilitate contributions to European or international standards, the EU-Rail grant agreements will include an additional information obligation related to standards. Beneficiaries must inform the EU-Rail JU (up to four years after the end of the action) if the results can be reasonably expected to contribute to European or international standards.</p> <p>As part of its internal control and management framework, the JU will perform a of reviews and maturity checkpoints to assess the overall progress against the project plan and against the performance and TRL targets. Depending on the outcome of these reviews and maturity checkpoints(s), the scope of the project may be revised and/or funding reduced in accordance with the provisions of the relevant grant agreement. Mitigation actions may be requested by the JU as condition for continued funding.</p> <p>The proposal shall consider the necessary resources – FTE and/or other – to ensure the monitoring of the “Flagship Project” via regular reporting, reporting of data for the Programme KPIs, etc.. A EU-Rail Governance and Process Handbook is available here: https://shift2rail.org/participate/</p>
Linked Projects	<p>As specified in section 2.3.3.2 of the AWP 2022, in order to facilitate the contribution to the achievement of the EU-Rail JU objectives, the options regarding 'linked actions' of the EU-Rail Model Grant Agreement and the provisions therein, is enabled in the corresponding EU-Rail JU Grant Agreements.</p> <p>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:</p> <ul style="list-style-type: none"> • HORIZON-ER-JU-2022-FA1-01: Network management planning and control & Mobility Management in a multimodal environment • HORIZON-ER-JU -2022-FA3-01: Intelligent & Integrated asset management • HORIZON-ER-JU -2022-FA4-01: A sustainable and green rail system • HORIZON-ER-JU -2022-FA5-01: Sustainable Competitive Digital Green Rail Freight Services • HORIZON-ER-JU -2022-FA6-01: Regional rail services / Innovative rail services to revitalise capillary lines <p>Please note that the list non-exhaustive as additional Linked Projects may follow at a later stage of the programme implementation to complement the activity.</p>
Funding of only one project per topic	<p>EU-Rail JU may award up to one project with funding depending on the outcome of the evaluation and the complementarity of the proposed actions.</p>

⁵⁷ Refer to the Multi-Annual Work Programme available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

Retroactive starting date of the grant	The starting date of grants awarded under this topic may be as of the submission date of the application. Applicants must justify the need for a retroactive starting date in their application. Costs incurred from the starting date of the action may be considered eligible.
Lump Sum grant	Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025). [[This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under ‘Simplified costs decisions’ or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lump-sum-decision_he_en.pdf]].
Lower funding rate	The funding rate of the action is 60% of the eligible costs to achieve the leverage effect established in the SBA. Each Consortia may decide internally different funding rates in line with the provisions of Article 34 of Horizon Europe nevertheless complying with the overall funding rate of 60%.
Award criteria additional details	The award criteria included in the General Annexes of the Horizon Europe – Work Programme 2021 – 2022 are complemented with additional criteria as specified in Annexe 8 this Work Programme.
Additional dissemination obligations	In addition, as specified in section 2.3.3.2 of the AWP 2022, and to facilitate contributions to considering the key contributing role of this topic, in designing the dissemination and communication activities, the proposal shall consider that the “Flagship Project” will be part of the overall EU-Rail Programme and the planning of key events – demonstrations, participations to fair, etc. – will be coordinated at Programme level and by the “Stakeholder Relations and Dissemination” structure of the JU.

Expected Outcome:

Operational solutions will cover a wide range of applications for next generation ATC technologies, such as passenger trains for high speed, light rail urban lines, suburban lines, freight trains and regional lines including low density lines as well as including application in more complex situations, such as mixed traffic, power supply transitions and ATP transitions (e.g. ETCS – undefined tracks). The action to the funded under this topic shall contribute to rail operation optimisation techniques.

The Flagship Project stemming from this topic is expected to contribute to Europe’s Rail Programme with the following outcomes, to be delivered on the basis of results stemming from the Shift2Rail programme and appropriately developed further in close coordination with SP development:

- Implementation of operational solutions to be demonstrated in specific use cases through demonstrators and technical enablers at TRL7 or above.. For next generation ATC

developments, principles of ATO over ETCS from S2R⁵⁸ (including the TSI CCS 2022 as a baseline) shall be used and where needed further developed.

- To secure investments and ensure an economic upgrade path, the evolution of DATO and next generation ATC shall support backwards compatibility for all automation levels. Furthermore, the overarching automation process (from TMS⁵⁹ to next generation ATC - ETCS and non-ETCS⁶⁰) shall also support end-to-end customer solutions independent from the existing infrastructure, to guarantee the automation of the operation over the entire value chain. In addition to the modularisation of the functionality of the ATC systems, the decoupling of software from hardware will pave the way for a modular hardware platform, as well as architectural software design patterns and methods enabling evolution⁶¹. Upgradeability shall be a clear goal- i.e. to use more modern technology for the same function or to enhance the GoA or ETCS Level. Special attention shall be given to cost effectiveness regarding maintainability and evolvability over lifetime and integration efforts.
- The following additional operational scenarios shall be considered in the development of the required technical enablers, services and functions:
 - Mixed operation for radio based ERTMS on lines with/without (mixed situation) Trackside Train Detection (TTD) and with L2 or L3 - capable vehicles of relevant system versions,
 - Train Integrity Monitoring System (TIMS) and localisation capabilities⁶² for different target configurations. To pave the way for an improved, faster infrastructure change from Class B to the previously defined scenarios with focus on shortening effort, prerequisites and duration (including simplified safety case effort, e.g., for changes) including integration with the modular ATC systems and the TMS.
 - “Fully mature ERTMS”: full supervision (cab signalling) continuously in all normal modes, also for shunting, or for yellow fleet movements.
 - The same architecture shall be used for efficient processes for train stabling, formation and preparation, as well as in marshalling yards, depots or terminals in connection with their specialized technologies for passenger and freight trains.

The Flagship Project stemming from this topic should deliver, by 2025, innovative solutions to be demonstrated under the following scenarios :

- ETCS game changers, including L3 moving block, hybrid level 3 and FRMCS, showing increased system capacity,
- Next-generation ATC, both for trackside and onboard, allowing fast and simplified deployment and upgradeability.
- ATO GoA3/4 over ETCS, including operational scenarios such as shunting, management of degraded modes, remote control, and cross-border operation, to assess the benefits of

⁵⁸ Public deliverables of S2R TD2.2 (ATO) available here: X2RAIL-1 : D4.1 and D4.3 : https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-1 and X2RAIL-4: D3.1 and D3.2: https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-4. In addition, relevance to S2R OC project SMART-2 and their work on obstacle detection: <https://smart2rail-project.net/deliverables/>

⁵⁹ Results from Shift2Rail activities should be taken into account, see TD2.9 (TMS) available here: WP6 deliverables: https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-2

⁶⁰ Results from Shift2Rail activities should be taken into account, see TAURO: D1.5 and D2.1 https://projects.shift2rail.org/s2r_ipx_n.aspx?p=tauro

⁶¹ Results from Shift2Rail activities should be taken into account, see TD1.2 (TCMS): CONNECTA projects (https://projects.shift2rail.org/s2r_ip1_n.aspx?p=CONNECTA-2) and SAFE4RAIL-2 (https://projects.shift2rail.org/s2r_ip1_n.aspx?p=SAFE4RAIL-2).

⁶² Results from Shift2Rail activities should be taken into account, see TD2.4 (train positioning) and TD2.5 (Onboard train integrity) deliverables from X2RAIL-2 (WP3 and WP4 deliverables available here: https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-2).

automation, namely the increased capacity, punctuality, flexibility, resilience and the reduced operating costs and energy consumption in at least four use cases:

- High density mainlines,
 - Regional low-traffic services in strong link with FA6,
 - Freight services, also considering self-driving freight wagons,
 - Inspection vehicles.
- Automation applied to light rail urban transport (i.e., tramways) in operation and in depots, and connected to other road users, to show the increased safety and punctuality and the reduced operational costs in the urban environment, to be scalable at European level.
Test validation platform, to enable the next-generation ATC technologies in an efficient cost-effective way.

The demonstrations of the innovative solutions should include interoperability aspects, challenging topology, and climate situations across Europe to show and assess the full impact of the next-generation ATC. This destination should deliver by 2025 at least the following:

- Demonstrate technical and functional enablers such as ATO GoA3/4 over mixed radio based ETCS levels (TRL7 or higher), Hybrid Level 3, moving block and TIMS (TRL6), connectivity (TRL7), perception (TRL6), train positioning (TRL6), automated functions and digital register (TRL6).
- Demonstration of the remote driving and command in depots and yards, including perception systems (TRL6).
- A first demonstrator on next generation ATC, with modular onboard and trackside ATC architectures, at proof-of-concept stage, in close collaboration with the EU Rail System Pillar.
- A proof-of-concepts and/or validation in laboratory and field (i.e., up to TRL5 in Lab and TRL6 on site) for the following new functions and technical enablers:
 - Virtual Coupling Train Set
 - Self-driving wagon
 - autonomous path allocation (linked to input from Destination1)
 - validation and certification
 - Demonstrate a Functional Open Coupling System prototype covering all required subsystems in an operational environment (TRL7)
 - Demonstrate a modular hardware platform using architectural software design patterns and methods (TRL7) allowing SIL2 respective SIL4 (depending on the application)

In addition of the above, the proposal shall cover important preparatory works to be launched for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions :

- integration of technical enablers and functions to enhance the performance and capabilities of next generation ATC supporting migration and enlarging the deployment scope of automation.
- ATO GoA3/4 in depots, yards and specific lines without train protection, shunting and stabling operations, and starting from ETCS L1 and non-supervised modes.
- preparation of next generation ATC with generic solutions and applications tailored to regional low-density traffic lines and first steps in highly automated urban light-rail operations.

The action to be funded under this Destination also needs to provide the following necessary element for the demonstrations under the action to be funded under Destination 5, Sustainable Competitive

Digital Green Rail Freight Services, to be delivered for 2025 demonstration: enablers 1, 3, 4, 7 and as described under the Scope section of this Destination. In addition of the above, the proposal shall cover important preparatory works needs to be launched for the future set of FA5 demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions, linked with the enablers 1, 4 and 7 at higher TRL.

The action to be funded under this Destination also needs to provide the following necessary element for the demonstrations under the action to be funded under Destination 6, Regional rail services/innovative rail services to revitalise capillary lines, to be delivered for 2025 demonstration : Enablers 2, 3, 4, 5, 6, 7, 9, 10 and 14 as described under the Scope section of this Destination. In addition of the above, the proposal shall cover important preparatory works needs to be launched for the future set of FA6 demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions, linked with those same enablers at higher TRL.

The action to be funded under this Destination also needs to provide the following necessary element for the demonstrations under the action to be funded under Destination 1, Network management planning and control & Mobility Management in a multimodal environment, to be delivered for 2025 demonstration: enablers 1 and 4 as described under the Scope section of this Destination, in addition to providing parameters for planning and simulation tools to calculate the capacity benefits. In addition of the above, the proposal shall cover important preparatory works needs to be launched for the future set of FA1 demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions, linked with those same enablers at higher TRL.

Scope:

The Flagship Project stemming from this topic should develop the following capabilities:

Capability for improving operation performance

Automating functions, such as the wake-up and train preparation capability is needed to start operation, causing the need for development within this Destination of:

- Enabler 1: Automating functions, such as **train preparation** for both passenger and freight trains. Incident handling, vehicle self-healing and self-managing, cooperative awareness at TRL5/6 in 2025 and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions, including remote control, auto-diagnostics, operational tests and reset capability of DATO and next generation ATC operated trains.

Trains must be continuously traceable for traffic control and train operators in automated operation. For this purpose, this Destination should develop:

- **Enablers 2 and 3: Absolute safe train positioning and train integrity** highly accurate and safe, incorporating new sensors at TRL5/6 in 2025.
- **Enabler 4: new ATO technology** solutions for the automated driving and decision-making, interoperable, and for all application and segments (including freight and regional) for commercial run at TRL 5/6 in 2025. It should include the already available integration of C-DAS and should include appropriate interfaces with TMS for energy network management;
- **Enabler 5: Connectivity solutions:** train to ground communication (FRMCS), Train to Train communication, Intra-train communication and V2X, at TRL7 in 2025.

Developments on all those enablers should also cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions.

Safe unattended operation must be ensured by **comprehensive, modular, and scalable perception systems (on-board and trackside) for both outdoor and indoor environments**. Systems shall be develop under this Demonstration for:

- **Enabler 6: Safe environment perception**, including signal reading (when applicable) and obstacle detection, supporting cooperative awareness, supported by virtual certification at TRL5/6 in 2025 and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions. In addition, such systems shall support the monitoring and diagnosis of assets, beyond the incident prevention functionalities.

In transition (either technical or operational) or shunting mode, automated train operation requires the development in this Destination of:

- **Enabler 7: Remote driving and command**, for depots, for lines with low traffic, and for fall-back operations as well as for shunting at TRL6 in 2025 and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions;

Additionally, the Destination should develop:

- **Enabler 8: Autonomous route setting**, on low traffic/regional networks, in terminals, in depots and in urban environment at TRL5 in 2025 and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions;
- **Enabler 9: a Digital Register**, acting as a central data source for, e.g., safe train positioning, ATP, TMS and DATO at TRL 6 in 2025.

Capability for offering more capacity to customers

Enabler 10: The combination of radio based ETCS (Level , Hybrid Level 3 and Level 3) and ATO is key to increase the capacity of railway lines. The development of the following enablers is therefore key: **ETCS Hybrid Level 3; ETCS Level 3 and Moving block systems**, taking into account aspects related to **relative braking distance**. Activities shall reach TRL6 for 2025 demonstration.

Enabler 11: A **fully fledged Virtual coupling**, another key element to achieve shorter headways and operational flexibility, supported by enhanced connectivity and localisation, shall also be developed, taking into account the outputs from the EU-Rail System Pillar.

Enabler 12: This development shall also include **self-driving freight wagons** (supporting cooperative awareness). Activities shall reach TRL4/5 for the 2025 demonstration.

Enabler 13: To maximise next generation ATC performance, building upon the work achieved in the S2R Programme, a **new generation of brake systems**⁶³ is needed to bring adjustable/configurable

⁶³ Public deliverables from S2R TD1.5 (brakes) from the project PINTA (D7.3, D8.1) available here: https://projects.shift2rail.org/s2r_ip1_n.aspx?p=PINTA

emergency brake control, the holding brake function and integrated adhesion management among other enhanced functionalities. New methods for qualification of brake performance under degraded adhesion, using adhesion management systems, are needed to allow performances to be assessed against a common framework as well as slide protection optimisation. This destination is expected to reach TRL5 for the 2025 demonstration.

Developments on all those enablers should also cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions.

Capability for supporting cost-effective deployment

Enabler 14: Technology as well and the operational procedures need to be validated and tested to ensure fast and safe deployment. To this end, this destination is expected to develop novel **platform and facilities for testing, validation and (virtual) certification**.⁶⁴ Developments should reach TRL 5/6 in 2025 and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions.

Enabler 15: Decoupling software from hardware and parts inside the software domain, and defining the steps needed to increase flexibility and reduce integration effort, need to be targeted. To make those improvements effective, an adapted development cycle including an adapted safety cases procedure and modularized certification is required for the reduction of integration efforts. This destination is therefore expected to develop railway industrial DevOps.

Capabilities enabling operational objectives:

The following enablers shall be developed:

- **Enabler 16:** Modular platform based on next generation ATC architectures, for agreed on-board and trackside modular architecture, reaching TRL6/7 in 2025, and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi-annual Work programme in view of the evolutions of the solutions .
- **Enabler 17:** Evolved onboard communication networks at TRL6 in 2025 and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi-annual Work programme in view of the evolutions of the solutions.
- **Enabler 18:** Functional Open Coupling System prototype covering all required subsystems in an operational environment (TRL7)
- Deployment and migration strategic plans, including training and human factors.

The action shall actively contribute to measure and monitor the specific quantitative KPIs defined in the Destination description above, including its contribution to the Europe's Rail Master Plan impacts.

The action shall actively contribute to the EU-Rail standardisation rolling development plans wherever relevant. Similarly, the action shall contribute to the development and implementation of EU policy and legislation including Technical Specifications for Interoperability and Common Safety Methods, as well as to publications of the System Pillar.

⁶⁴ Public deliverable of S2R TD2.6 (Zero on-site testing) available here: https://projects.shift2rail.org/s2r_ip_TD_r.aspx?ip=2&td=983bce09-d662-47ac-904c-a543f5b73fcc

Collaboration work required with other FAs

The action to be funded under Destination 2 shall foresee a common activity/task related to capturing specific requirements and review of system specifications relevant to the actions to be funded under Destination 5 and Destination 6.

The action to be funded under Destination 2 shall foresee a common activity/task related to the Preparatory works on the integration and pilot test(s) of the technical enablers to be provided to the actions to be funded under Destination 1, Destination 5 and Destination 6 for the demonstration to be carried out in the action to be funded by Destination 1, Destination 5 and Destination 6.

Interaction with the System Pillar

The System Pillar aims to guide, support and secure the work of the Innovation Pillar (i.e. to ensure that research is targeted on commonly agreed and shared customer requirements and operational needs, compatible and aligned to the system architecture), and the Innovation Pillar will impact the scope of the System Pillar where new technologies or processes mean that innovations can drive a change in approach, as well as delivering detailed specifications and requirements.

In this respect, the proposal should allocate necessary resources that would be dedicated to areas linked to the System Pillar conceptual and architecture works – particularly addressing specification development (the interaction is illustrated in the System Pillar – Innovation Pillar interaction note (Annex VI of this Work Programme)). The alignment of the activities will primarily take place during the Grant Preparation Phase and ramp up phase of the awarded proposal, and there will be continued, structured and regular interaction through the life of the project.

Interaction with other relevant actions

Work under this topic should link to relevant actions, when appropriate, financed by the European Space Agency (ESA), the European Union Agency for the Space Programme (EUSPA), the project 5Grail (GA number: 951725) and the Connecting Europe Facility (CEF2), and in particular with actions to be funded under the calls CEF-DIG-2021-5GCORRIDORS-WORKS and TOPIC ID: CEF-DIG-2021-5GCORRIDORS-WORKS. Link to other external initiatives can also be relevant.

Gender dimension

In this topic the integration of the gender dimension (sex and gender analysis) in research and innovation content is not a mandatory requirement.

3. DESTINATION 3 – Intelligent & Integrated asset management

DESTINATION 3 – description (possibly included in the Expected Outcome in the Funding Portal)

The financial and, to a certain extent, environmental costs associated with designing, building, constructing, operating, maintaining, and decommissioning rail drive also its capacity to compete and offer attractive services for the clients, passengers and supply chain. Therefore, rail asset management is a key area for research and innovation.

In the vision of the future rail asset management, assets status evolution information will be integrated with TMS (Traffic Management System) to improve services, reducing unavailability by limiting the impact of in-service failures and/or providing alternative solutions without cost impacts, and increasing safety. Moreover, the available information combined with AI (Artificial Intelligence) and digital twins will introduce intelligence to the management and optimize the overall life cycle and operation of the rail system.

The selected proposal for funding under this Destination will be a Flagship Project of Europe's Rail with significant expected impacts, which require an integrated sector systemic approach. Proposals, should therefore set out a credible pathway (including an exploitation plan) to contributing to all of the following expected impacts as described in the Master Plan.



These can be further detailed with specific impacts of this destination, as:

- Increase the volumes of rail transportation on existing lines
- Improve the cost-effectiveness of rail transportation on existing lines
- Reduce the CO₂ emissions from the maintenance of existing lines
- Reduce the construction time and costs of new assets
- Increase in durability and reliability of assets
- Optimise life-cycle costs of assets
- Strengthen European rail industry competitiveness with more qualified products
- Improve Flexibility and punctuality of the railway system

Proposals under this Destination should set appropriate monitoring and demonstration activities to measure the following KPIs:

#	Demonstrator Name	High level theme and result	KPI's
1	Asset Management & TMS	Integration of Intelligent Asset Management System (IAMS) & TMS	I. Qualitative and prompt integration of information, including reducing time to transfer asset condition status to TMS by 50 %, in specific use cases
2	Asset Management & Rolling Stock	Asset Management of Rolling Stock Operation, including specific solutions for freight	II. reduction of maintenance costs up to 10% in specific use case, and/or III. 25% reduction of in-service failures IV. increasing rolling stock availability respective reducing workshop downtime targeting 10% in specific use cases
3	Long Term Asset Management	Infrastructure & Rolling Stock long-term Asset Management	V. Tools which provide at least 3 possible strategies of long term management with an accuracy (as defined by ISO) improvement of 10%
4	Asset Management & Infrastructure	Asset Management of Infrastructure Operation	VI. reduction of maintenance costs targeting 10% in specific use case, and/or VII. 25% reduction of in-service failures
5	Asset Management & Digital Twins	Digital Twin Asset Management, addressing both Rolling Stock & Infrastructure	VIII. The number of assets managed and monitored by Digital Twins is increased by 25 %
6	Design & Manufacturing	Advanced and Holistic Design	IX. For repair: Extension of remaining life 25% X. 20% time reduction (from design to manufacturing) XI. 20% cost reduction
7	Robotics & Interventions	Remotely controlled and unmanned interventions	XII. Increased accuracy of inspections of 25% with respect to conventional interventions and/or XIII. Reproducibility of inspections of 25% with respect to conventional interventions XIV. Cost reduction of the interventions by at least 10%

The following call in this work programme contribute to this Destination:

Call	Budgets (EUR million)			Deadline
	2021/2022	2023	2024	
HORIZON-ER-JU-2022-01	26.9	14.5	4.9	23 June 2022

Minimum overall indicative budget	46.3	
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Call: HORIZON-ER-JU-2022-01

Conditions for the Call

Indicative budget(s)

Topics	Type of Action	Budgets (EUR million)			Expected EU contribution per project (EUR million) ⁶⁵	Number of projects expected to be funded
		2021/2022	2023	2024		
	Opening: 10 March 2022 Deadline(s): 23 June 2022					
HORIZON-ER-JU-2022-FA3-01	IA	26.9	14.5	4.9	46.3	1
Overall indicative budget		46.3				

General conditions relating to this call	
<i>Admissibility conditions</i>	The conditions are described in part A of the General Annexes to the Horizon Europe Work Programme 2021-2022
<i>Eligibility conditions</i>	The conditions are described in part B of the General Annexes to the Horizon Europe Work Programme 2021-2022
<i>Financial and operational capacity and exclusion</i>	The criteria are described in part C of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Award criteria</i>	The criteria are described in part D of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Documents</i>	The documents are described in part E of the General Annexes to the Horizon Europe Work Programme 2021-2022.

⁶⁵ Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

<i>Procedure</i>	The procedure is described in part F of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Legal and financial set-up of the Grant Agreements</i>	The rules are described in part G of the General Annexes to the Horizon Europe Work Programme 2021-2022.

Proposals are invited against the following topic(s):

HORIZON-ER-JU-2022-FA3-01: Intelligent & Integrated asset management

Specific Conditions	
Expected EU contribution per project	EU-Rail estimates that an EU contribution of EUR 46.3 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	<p>The total indicative budget for the topic is EUR 46.3 million.</p> <p>Applicant Private⁶⁶ Members of the EU-Rail JU part of consortia responding to this topic should provide in-kind contributions to additional activities to be declared via the template model available on the F&T portal. The amount of total in-kind contributions (i.e. in-kind contributions for operational activities and in-kind contributions for additional activities) should be no less than 1.263⁶⁷ times the funding request, in aggregate, of these applicant Private Members. Any discrepancy shall be well and duly justified.</p> <p>In this respect, the grant agreements will set, in principle, annual deliverable on in-kind contributions for the projects selected under this topic, as well as mandatory reporting requirements, for those applicants who are Private Members of the EU-Rail JU.</p>
Indicative project duration	48 months.
Type of Action	Innovation Action
Technology Readiness Level	Activities are expected to achieve a minimum between TRL 5 and TRL 8, depending on the enabler addressed, or higher by the end of the project – see General Annex B for a guide to the TRL definitions and criteria to be used.
Admissibility conditions	Regarding admissibility conditions and related requirements, part A of the Horizon Europe Work Programme 2021-2022 General Annexes applies with the following exception: the limit for a full Innovation Action application is set to 120 pages.

⁶⁶ As defined in Article 2(5) of Council Regulation (EU) 2021/2085.

⁶⁷ In order to support a leverage factor of no less than the ratio between the contribution from members other than the Union and the Union financial contribution, as on the basis of Articles 88 and 89 of Council Regulation (EU) 2021/2085.

Special skills and/or capabilities expected from the Applicant(s)	<p>Applicants shall ensure that their proposals and consortium reflect the aggregated expertise to perform the activities and achieve the objectives set by the Destination:</p> <ul style="list-style-type: none"> • Expertise from rail infrastructure managers and railway undertakings, which should allow <ul style="list-style-type: none"> – defining main challenges, use cases and functional needs, – specifying, prioritizing and clustering demonstrators to ensure that researched innovative processes, operational and technological solutions are covered, – hosting the demonstrations and providing test trains/facilities, – providing data structures and content as well as processes, e.g. certification which can be subject for digitalisation. • Expertise from rail suppliers (system integrators, manufacturers and/or technology providers), which should allow, jointly, <ul style="list-style-type: none"> – proposing operational and technological innovative solutions to identified use cases and functional needs, – identifying the technical requirements and interface specifications, aligned with the System Pillar architecture, – designing, developing, prototyping and delivering innovative operational & technological solutions and systems to be integrated within the demonstrations, depending on the specific target TRL level. • Expertise from research institutes and academia, which should allow <ul style="list-style-type: none"> – planning, developing, studying, testing and evaluating solutions, systems and demonstrators together with the previous categories of expertise, – supporting any possible scientific or methodological issues that may arise during the performance of the action – contributing to other aspects of the innovation cycle, as well as to the procedural aspects for validation, certification, etc. • Complementary expertise from other sectors and parties, with particular attention to SMEs and Start-ups, which may contribute to enhance the actions' outcome.
Contribution to the monitoring and implementation, standardisation of the EU-Rail Programme	<p>The action resulting from this topic is identified as a “flagship project” expected to perform, by the completion of the research and innovation lifecycle, “large scale demonstrations”, in the meaning of Council Regulation (EU) 2021/2085. Hence, the action is a key contributor to the achievement of the objectives identified in the Master Plan⁶⁸ as further detailed in the Multi-Annual Work Programme⁶⁹.</p> <p>In this respect, applicants are expected to deliver relevant information (data, results, etc.) as mutually agreed, to the JU and the Linked Project[s] to contribute to the advancement of the Innovation and System Pillars⁷⁰ activities, as well as in view of the development and implementation of EU policy and legislation (including Technical Specifications for Interoperability and Common Safety</p>

⁶⁸ Master Plan available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

⁶⁹ MAWP available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

⁷⁰ Refer to the Multi-Annual Work Programme available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

	<p>Methods) and the development of European standards. As specified in section 2.3.3.2 of the AWP 2022, and to facilitate contributions to European or international standards, the EU-Rail grant agreements will include an additional information obligation related to standards. Beneficiaries must inform the EU-Rail JU (up to four years after the end of the action) if the results can be reasonably expected to contribute to European or international standards.</p> <p>As part of its internal control and management framework, the JU will perform a of reviews and maturity checkpoints to assess the overall progress against the project plan and against the performance and TRL targets. Depending on the outcome of these reviews and maturity checkpoints(s), the scope of the project may be revised and/or funding reduced in accordance with the provisions of the relevant grant agreement. Mitigation actions may be requested by the JU as condition for continued funding.</p> <p>The proposal shall consider the necessary resources – FTE and/or other – to ensure the monitoring of the “Flagship Project” via regular reporting, reporting of data for the Programme KPIs, etc.. A EU-Rail Governance and Process Handbook is available here : https://shift2rail.org/participate/ In addition, as specified in section 2.3.3.2 of the AWP 2022, and to facilitate contributions to considering the key contributing role of this topic, in designing the dissemination and communication activities, the proposal shall consider that the “Flagship Project” will be part of the overall EU-Rail Programme and the planning of key events – demonstrations, participations to fair, etc. – will be coordinated at Programme level and by the “Stakeholder Relations and Dissemination” structure of the JU.</p>
Linked Projects	<p>As specified in section 2.3.3.2 of the AWP 2022, in order to facilitate the contribution to the achievement of the EU-Rail JU objectives, the options regarding 'linked actions' of the EU-Rail Model Grant Agreement and the provisions therein, is enabled in the corresponding EU-Rail JU Grant Agreements.</p> <p>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:</p> <ul style="list-style-type: none"> • HORIZON-ER-JU -2022-FA1-01: Network management planning and control & Mobility Management in a multimodal environment and Digital Enablers • HORIZON-ER-JU -2022-FA2-01: Digital & Automatic up to Automated Train Operations • HORIZON-ER-JU -2022-FA4-01: A sustainable and green rail system • HORIZON-ER-JU -2022-FA5-01: Sustainable Competitive Digital Green Rail Freight Services • HORIZON-ER-JU -2022-FA6-01: Regional rail services / Innovative rail services to revitalise capillary lines <p>Please note that the list non-exhaustive as additional Linked Projects may follow at a later stage of the programme implementation to complement the activity.</p>

Funding of only one project per topic	EU-Rail JU may award up to one project with funding depending on the outcome of the evaluation and the complementarity of the proposed actions.
Retroactive starting date of the grant	The starting date of grants awarded under this topic may be as of the submission date of the application. Applicants must justify the need for a retroactive starting date in their application. Costs incurred from the starting date of the action may be considered eligible.
Lump Sum grant	Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025). [[This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under ‘Simplified costs decisions’ or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lump-sum-decision_he_en.pdf]].
Lower funding rate	The funding rate of the action is 60% of the eligible costs to achieve the leverage effect established in the SBA. Each Consortia may decide internally different funding rates in line with the provisions of Article 34 of Horizon Europe nevertheless complying with the overall funding rate of 60%.
Award criteria additional details	The award criteria included in the General Annexes of the Horizon Europe – Work Programme 2021 – 2022 are complemented with additional criteria as specified in Annexe 8 this Work Programme.
Additional dissemination obligations	In addition, as specified in section 2.3.3.2 of the AWP 2022, and to facilitate contributions to considering the key contributing role of this topic, in designing the dissemination and communication activities, the proposal shall consider that the “Flagship Project” will be part of the overall EU-Rail Programme and the planning of key events – demonstrations, participations to fair, etc. – will be coordinated at Programme level and by the “Stakeholder Relations and Dissemination” structure of the JU.

Expected Outcome:

To achieve the overall goal of this destination, five high-level capabilities have been identified, and the expected solutions should integrate the following:

Information sharing across the supply chain and TMS

The focus is on the ability to capture and share information securely across the entire rail system lifecycle, including operation, of rail assets. Furthermore, this area of action includes the secure

exchange of information between the existing TMS⁷¹ and the Intelligent Asset Management System⁷² (IAMS).

Unmanned and non-invasive monitoring and inspections

Building upon the work delivered by IP3⁷³ in S2R and other research and innovation activities, the objective is to enhance the capability for automated and unmanned inspection and monitoring, evolving towards non-invasive and self-diagnostic systems with no or minimal service disruptions.

Advanced and holistic asset decisions

Building upon the work delivered by IP3⁷³ in S2R and other research and innovation, the focus is on the capability of making decisions in an advanced, automated, centralised, and holistic manner, considering the different assets, actors, standards, and regulations, especially combining track and rolling stock data. Furthermore, Digital Twins and enhanced visualisation techniques shall be exploited to support decision-making.

Advanced and holistic design and certification of assets (including virtual certification)

Building upon the work delivered by S2R⁷⁴ and other research and innovation, this outcome has a clear focus on the development of newly deployed components for the rail system with a LCC and system performance approach. Furthermore, in conjunction with the following capability, the use of additive manufacturing techniques shall be addressed, as well as the use of self-healing techniques and materials.

Remotely controlled and unmanned interventions

Building upon the work delivered by IP3⁷⁵ in S2R and other research and innovation, the objective is the development of capabilities for remote, automated, and unmanned intervention actions in rail systems. This shall make use of various technologies, including from other industries, such as robotics

⁷¹ Results from Shift2Rail activities should be taken into account, see public deliverables of S2R TD2.9 (TMS) available here: WP6 deliverables: https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-2

⁷² Results from Shift2Rail activities should be taken into account, see public deliverable of S2R TD3.6, TD3.7 and TD3.8 (IAMS) available here: IN2SMART-2 - D3.1

<https://projects.shift2rail.org/download.aspx?id=1fc574ec-1a28-4199-b77b-402d352d62f0>

⁷³ public deliverables of S2R TD3.6, TD3.7 and TD3.8 (IAMS) available here:

IN2SMART (D9.1 ; D8.5 ; D7.4 ; D7.3 ; D7.2 ; D7.1 ; D4.1 ; D3.5): https://projects.shift2rail.org/s2r_ip3_n.aspx?p=IN2SMART
MOMIT (D1.1 ; D1.2 ; D1.3 ; D2.1 ; D2.2 ; D3.1 ; D3.2 ; D4.1 ; D4.2): https://projects.shift2rail.org/s2r_ip3_n.aspx?p=MOMIT
IN2DREAMS (D5.1; D5.3 ; D5.4): https://projects.shift2rail.org/s2r_ip3_n.aspx?p=S2R_IN2DREAMS

⁷⁴ Public deliverables of S2R TD3.1 to 3.5 available here :IN2TRACK (D2.1 ; D2.2 ; D2.3 ; D3.1 ; D3.2 ; D3.3 ; D4.1): https://projects.shift2rail.org/s2r_ip3_n.aspx?p=IN2TRACK

Public deliverable of CCA WA3.5 - Virtual Certification available here :

PLASA2 – WP5: https://projects.shift2rail.org/s2r_ipcc_n.aspx?p=plasa-2

⁷⁵ Public deliverable of S2R TD3.8 (Lean Execution) available here:

IN2SMART – WP10: https://projects.shift2rail.org/s2r_ip3_n.aspx?p=IN2SMART

and wearable devices to support rail personnel, improve safety and increase the efficiency of intervention tasks.

The Flagship Project stemming from this topic should deliver, by 2025, innovative solutions to be demonstrated under the following **high-level principles**:

- a. The integration of the complete value chain.
- b. The exploitation of synergies between stakeholders at different levels, for instance, with respect to crossed monitoring.
- c. The prioritisation of activities to achieve 2030 European objectives in rail mobility, exploiting Shift2Rail results.

The demonstrators for innovative solutions shall have several **operational differences** to be covered, including:

- **Climate.** The proposed solutions shall have to be able to take into account the wide variety of European climate types.
- **Line type.** Demonstrators shall address high speed, conventional, regional, suburban and freight lines.
- **Traffic type.** Demonstrators shall cover passenger, freight and mixed lines.
- **Asset type.** Infrastructure and rolling stock shall be addressed jointly whenever possible considering all assets, including track, civil structures, earthworks, signalling, vehicles, track side, stations or power infrastructures.
- **Planning level.** demonstrators shall cover the Strategic Asset Management Plan level (SAMP), the Asset Management Plan level (AMP) and the Implementation of the Asset Management Plan level (IAMP).

The destination shall research, develop and deliver solutions that can be demonstrated by system approaches of the various developments targeting up to TRL 6 as European common integrated solutions. Due consideration should be given to certification and validation of the new technologies and processes as part of those demonstrators, that may be supported by several Use Cases:

1. **Asset Management & TMS.** The main aim of the demonstrator shall be to show the integration between the Intelligent Asset Management System (IAMS) and the Traffic Management System (TMS) enabling the sharing of data and optimising decisions using common metrics – TRL6 by 2025.
2. **Asset Management & Rolling Stock.** The main objective of this demonstrator shall be to present the monitoring of rolling stock (including on board and wayside technologies) leading to decisions and planning of interventions, and redirecting rolling stock to workshops to execute the (re)scheduled work both manually as well as by new technologies and solutions to conduct inspection tasks automatically – TRL6 by 2025..
3. **Long Term Asset Management.** Development of Life Cycle Cost (LCC) models for infrastructure and rolling stock. This demonstrator shall include cross-border infrastructure remaining useful-life analysis and space-time cross-analysis and visualisation – TRL6 by 2025.
4. **Asset Management & Infrastructure.** The objective shall be to integrate on field and on board systems with central platforms capable of managing Big Data to enable prescriptive interventions, minimising dangerous situations and service disruptions during operation – TRL6 by 2025.

5. **Asset Management & Digital Twins.** The focus shall be on design, maintenance, upgrade and renewal interventions driven by Digital Twins for the optimisation of processes, maintenance planning and involved logistics. This shall enforce the use of BIM to standardise system configuration and AI tools to execute simulations and predictions. The Digital Twin demonstrator shall include visualisation, prediction and simulation – TRL7 by 2025.
6. **Design & Manufacturing.** This demonstrator shall be the showcase of eco-friendly production of resilient assets supported by new fabrication techniques such as additive manufacturing (focussed on infrastructure assets) – TRL5 by 2025
7. **Robotics & Interventions.** The focus of this demonstrator shall be the showcase of high-tech automated execution solutions for construction and interventions supported by robotics and wearables, among other devices, building a safer and more automated railway environment.- TRL5/6 by 2025

Each of these high-level demonstrators shall be further detailed and filled with specific, tangible and suitable use cases illustrating the impact of the technologies in concrete solutions. The choice of these use cases shall be based on sound business cases supported by a wide range of stakeholders possibly covering a wide range of assets proofing the versatility of the technologies, such as:

- Physical infrastructure: track, civil structures, earthworks, signalling, track side, stations or power infrastructures.
- Rolling stock: passenger service, freight and light/urban vehicles.

The business cases shall illustrate that major and widely recognised pain points are addressed ensuring that the wide deployment of the outcomes will contribute to a significant improvement in cost reduction, direct cost or LCC and/or reliability of the system or work conditions.

Where an opportunity would materialize to achieve more aggregated demonstrators, especially linking demonstrators in the area of asset management, in business cases that will link digital twins, TMS and asset management for rolling stock and/or infrastructure, this should be pursued.

The action to be funded under this Destination also needs to provide the following necessary elements for the demonstrations under the action to be funded under the **Destination 5 – Sustainable Competitive Digital Green Rail Freight Services** to be delivered for 2025 demonstrations: enabler 3 as described under the Scope section of this Destination. In addition of the above, the proposal shall cover important preparatory works needs to be launched for the future set of FA5 demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions, linked with the same enabler at higher TRL.

The action to be funded under this Destination also needs to be provide the following necessary elements for the demonstrations under the action to be funded under the **Destination 1 – Network management planning and control & Mobility Management in a multimodal environment** to be delivered for 2025 demonstrations: enabler 1 as described under the Scope section of this Destination. In addition of the above, the proposal shall cover important preparatory works needs to be launched for the future set of FA1 demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions, linked with the same enabler at higher TRL.

Scope:

The Flagship Project stemming from this topic shall develop under the following capabilities the enablers and any other which may contribute to deliver the aforementioned expected outcome:

Capability for Information sharing across the supply chain and TMS

Enabler 1: Scalable information platform to integrate and exchange information (e.g., asset health, maintenance planning, fleet operation, etc.) across the supply chain and TMS, requiring necessary management and sharing agreements between the involved actors at TRL6 in 2025, amongst others:

- secure standardised interfaces, methods, and processes for different data exchange (e.g., inspection devices to Asset Management Platform, etc.) at TRL6 in 2025, and
- high performance and/or edge computing solutions coupled with secure, wired, and wireless communication networks for information sharing at TRL6 in 2025.

Developments on all those enablers should also cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions.

Capability for Unmanned and non-invasive monitoring and inspections

Enabler 2: Improved (in terms of cost reduction and/or better accuracy) asset diagnostic and inspection systems, as well as advanced, context aware, unmanned automated monitoring and inspections solutions at TRL6 in 2025, amongst others:

- AI and ML solutions and data fusion algorithms respectively to analyse and combine information provided by different inspection techniques at TRL6 in 2025;
- Secure standardised interfaces for different data exchange with precise time-stamping, synchronisation and accurate positioning solutions for data integrity at TRL6 in 2025; and
- energy-efficient inspection solutions with harvesting techniques and specific embedded wired and wireless communication networks at TRL6 in 2025;

More specifically, one Use Case shall address:

Enabler 3: Development of CBM methodologies and algorithms to be potentially exploited by the DAC based digital applications on CBM (TRL7) in 2025.

Developments on all those enablers should also cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions.

Capability for Advanced and holistic asset decisions

Enabler4: New methodologies and technologies to leverage advanced and holistic asset decisions during the span of their life cycle at TRL6 in 2025, based on:

- probabilistic models for standardised railway asset LCC determination and for component failure in the asset maintenance decision strategy, at TRL6 in 2025
- operational and IoT data with additional rail system information and knowledge integrated with technologies to enable cooperative diagnostic between assets at TRL8 in 2025

- AI-based hybrid Decision Support based on predictive and prescriptive data analytics and Machine Learning algorithms for anomaly detection and failure prediction with optimised human-AI interactions at TRL6 in 2025

Enabler 5: Digital Twins integrated with BIM, GIS tools, and Virtual and Augmented Reality to enable agile visualization for different stakeholders of asset health status (historical, current, and forecasted) in various use cases at TRL 7 in 2025.

Developments on all those enablers should also cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions.

Capability for Advanced and holistic design and certification of assets

Enabler 6: Advanced and holistic design and certification of assets, at TRL 5 in 2025, based on new ethical-by-design materials with advanced LCC characteristics, automated certification techniques (including virtual certification), and advanced embedded sensors for self-diagnostic materials.

Capability for Remotely controlled, unmanned and metadata-assisted interventions

Enabler 7: Development of remotely controlled, unmanned and metadata-assisted interventions in construction, maintenance, and renewal operations, based on:

- non-invasive or collaborative unmanned robotic actuators and wearables at TRL5 as well as vehicles based on AI and ML at TRL6 in 2025, and
- additive manufacturing techniques and validation standards for manufacturing and repairing assets at TRL 6 in 2025.

Developments on all those enablers should also cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions.

The action shall actively contribute to measure and monitor the specific quantitative KPIs defined in the Destination description above, including its contribution to the Europe's Rail Master Plan impacts.

The action shall actively contribute to the EU-Rail standardisation rolling development plans wherever relevant. Similarly, the action shall contribute to the development and implementation of EU policy and legislation including Technical Specifications for Interoperability and Common Safety Methods, as well as to publications of the System Pillar.

Collaboration work required with other FAs

The action to be funded under Destination 3 shall foresee a common activity/task related to capturing specific requirements and review of specifications relevant to the actions to be funded under Destination 1 and 5.

Interaction with the System Pillar

The System Pillar aims to guide, support and secure the work of the Innovation Pillar (i.e. to ensure that research is targeted on commonly agreed and shared customer requirements and operational needs, compatible and aligned to the system architecture), and the Innovation Pillar will impact the scope of the System Pillar where new technologies or processes mean that innovations can drive a change in approach, as well as delivering detailed specifications and requirements.

In this respect, the necessary resources would have to be dedicated to areas linked to System Pillar conceptual and architecture works – particularly addressing specification development (the interaction is illustrated in the System Pillar – Innovation Pillar interaction note (Annex VI of this Work Programme). The alignment of the activities will primarily take place during the Grant Preparation Phase and ramp up phase of the awarded proposal, and there will be continued interaction through the life of the project.

Gender dimension

In this topic the integration of the gender dimension (sex and gender analysis) in research and innovation content is not a mandatory requirement.

4. DESTINATION 4 – A sustainable and green rail system

DESTINATION 4 – description (possibly included in the Expected Outcome in the Funding Portal)

In order to improve the existing sustainability performances of railway systems, new innovative products and services need to be developed, tested and deployed. On the basis of leading-edge technologies to minimize the overall energy and resource consumption and environmental impact of the railway system, the aim of this destination is to accomplish a more attractive and climate resilient mode of transport. With the cooperation of the whole European rail value chain, the target is to optimise performances, stimulate the modal shift and improve passenger experience. Given the level of investments needed towards decarbonation of the overall rail system, the R&I activities will contribute to the objective of a Climate Neutral Europe for 2050. This means:

- Innovative solutions to minimise environmental footprint of the overall rail system., including less resource-intensive materials (infrastructure, rolling stock and operational).
- Holistic approach towards generation, storage and optimal use of energy in the infrastructure connected to the European energy network.
- Innovative approaches to design and use, focused on increased capacity and modularity of solutions (tools, manufacturing processes and efficient use of resources)
- Systems improvement including electro-mechanical components for low consumption, low emissions, low noise and low vibration levels.
- Healthier and safer subsystems such as air-filtration, disinfection systems and eco-friendly HVAC technologies.
- New designs of rolling-stock especially modular interiors for a more adaptative, attractive and economically sustainable railway transport for passengers and supported by industrial standards.

The selected proposal for funding under this Destination will be a Flagship Project of Europe's Rail with significant expected impacts, which require an integrated sector systemic approach. Proposals, should therefore set out a credible pathway (including an exploitation plan) to contributing to all of the following expected impacts as described in the Master Plan.



Meeting
evolving
customer
requirements



Improved EU rail
supply industry
competitiveness



Reduced costs



More sustainable
and resilient
transport



Improved
performance and
capacity

These can be further detailed with specific impacts of this destination, as:

- Reducing energy consumption. The continuous technologies evolution leads to significant decrease of energy consumption. Acceleration towards a zero CO_{2e} emission rail system.
- Bosting alternatives to the use of fossil fuels are unavoidable for the overall European rail system. Every potential solution, mainly energy storage system and hydrogen (H₂) have to be considered.
- Defining the industrial standards that will support the need to demonstrate and prove rail as the greenest mode of transport, easing the transformation of the rail system in a circular economy model while ensuring resilience to external risks, such as climate change.

- Regarding the attractiveness of the vehicles, shared concepts and the relevant industrial standards will ease quicker and greener transformation of the European rail vehicles.

Proposals under this Destination should set appropriate monitoring and demonstration activities to measure the following KPIs:

KPI Title / Type of impact	Dimension / KPI	Baseline / Expected improvement
Autonomy. Linked to sustainability via CO2 reduction on Diesel regional trains	Extended reach (km)	Baseline 80km and target 200km for regional trains
Physical energy consumption (train, infrastructure, station)	kWh/passenger.km kg CO2/year.m2 kg H2/vehicle.ton.km	Existing electric railways and up to 30% in specific use cases (linked also to ATO – DAS, HVAC, airless train for energy consumption reduction and innovative traction systems)
Physical CO2 equivalent emissions (LCA) linked to new propulsion systems, stations and infrastructure	kg CO2/passenger.km kg CO2/year.m2	Up to 30% for specific use cases (e.g. different fleets on specific railway lines, reduction to 0% for regional trains on non-electrified lines by substitution of Diesel by battery/H2 and heavy duty inspection vehicles)
Noise emitted by train, infrastructure at component level	dB(A)	Between 3-8dB for specific use cases on existing electric railways, Diesel, Hydrogen trains, infrastructure, stations. (e.g. brakes (compressor), HVAC subsystems, pre-heating operations, depots facilities)
Life Cycle Costs reduction	%	Between 5-10% for specific use cases including externalities costs

The following call(s) in this work programme contribute to this Destination:

Call	Budgets (EUR million)			Deadline
	2021/2022	2023	2024	
HORIZON-ER-JU-2022-01	22.2	12.0	4.1	23 June 2022
Minimum overall indicative budget	38.3			

Call: HORIZON-ER-JU-2022-01

Conditions for the Call

Indicative budget(s)

Topics	Type of Action	Budgets (EUR million)			Expected EU contribution per project (EUR million) ⁷⁶	Number of projects expected to be funded
		2021/2022	2023	2024		
	Opening: 10 March 2022 Deadline(s): 23 June 2022					
HORIZON-ER-JU-2022-FA4-01	IA	22.2	12.0	4.1	38.3	1
Overall indicative budget		38.3				

General conditions relating to this call	
<i>Admissibility conditions</i>	The conditions are described in part A of the General Annexes to the Horizon Europe Work Programme 2021-2022
<i>Eligibility conditions</i>	The conditions are described in part B of the General Annexes to the Horizon Europe Work Programme 2021-2022
<i>Financial and operational capacity and exclusion</i>	The criteria are described in part C of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Award criteria</i>	The criteria are described in part D of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Documents</i>	The documents are described in part E of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Procedure</i>	The procedure is described in part F of the General Annexes to the Horizon Europe Work Programme 2021-2022.

⁷⁶ Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

<i>Legal and financial set-up of the Grant Agreements</i>	The rules are described in part G of the General Annexes to the Horizon Europe Work Programme 2021-2022.
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HORIZON-ER-JU-2022-FA4-01: A sustainable and green rail system

Specific Conditions	
Expected EU contribution per project	EU-Rail estimates that an EU contribution of EUR 38.3 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	<p>The total indicative budget for the topic is EUR 38.3 million.</p> <p>Applicant Private⁷⁷ Members of the EU-Rail JU part of consortia responding to this topic should provide in-kind contributions to additional activities to be declared via the template model available on the F&T portal. The amount of total in-kind contributions (i.e. in-kind contributions for operational activities and in-kind contributions for additional activities) should be no less than 1.263⁷⁸ times the funding request, in aggregate, of these applicant Private Members. Any discrepancy shall be well and duly justified.</p> <p>In this respect, the grant agreements will set, in principle, annual deliverable on in-kind contributions for the projects selected under this topic, as well as mandatory reporting requirements, for those applicants who are Private Members of the EU-Rail JU.</p>
Indicative project duration	48 months.
Type of Action	Innovation Action
Technology Readiness Level	Activities are expected to achieve a minimum between TRL 5 and TRL 7, depending on the enabler addressed, or higher by the end of the project – see General Annex B for a guide to the TRL definitions and criteria to be used.
Admissibility conditions	Regarding admissibility conditions and related requirements, part A of the Horizon Europe Work Programme 2021-2022 General Annexes applies with the following exception: the limit for a full Innovation Action application is set to 120 pages.
Special skills and/or capabilities expected from the Applicant(s)	<p>Applicants shall ensure that their proposals and consortium reflect the aggregated expertise to perform the activities and achieve the objectives set by the Destination:</p> <ul style="list-style-type: none"> • Expertise from rail infrastructure managers and railway undertakings, which should allow

⁷⁷ As defined in Article 2(5) of Council Regulation (EU) 2021/2085.

⁷⁸ In order to support a leverage factor of no less than the ratio between the contribution from members other than the Union and the Union financial contribution, as on the basis of Articles 88 and 89 of Council Regulation (EU) 2021/2085.

	<ul style="list-style-type: none"> – defining main challenges, use cases and functional needs, – specifying, prioritizing and clustering demonstrators to ensure that researched innovative processes, operational and technological solutions are covered, – hosting the demonstrations and providing test trains/facilities, – providing data structures and content as well as processes, e.g. certification which can be subject for digitalisation. <ul style="list-style-type: none"> • Expertise from rail suppliers (system integrators, manufacturers and/or technology providers), which should allow, jointly, <ul style="list-style-type: none"> – proposing operational and technological innovative solutions to identified use cases and functional needs, – identifying the technical requirements and interface specifications, aligned with the System Pillar architecture, – designing, developing, prototyping and delivering innovative operational & technological solutions and systems to be integrated within the demonstrations, depending on the specific target TRL level. • Expertise from research institutes and academia, which should allow <ul style="list-style-type: none"> – planning, developing, studying, testing and evaluating solutions, systems and demonstrators together with the previous categories of expertise, – supporting any possible scientific or methodological issues that may arise during the performance of the action – contributing to other aspects of the innovation cycle, as well as to the procedural aspects for validation, certification, etc. • Complementary expertise from other sectors and parties, with particular attention to SMEs and Start-ups, which may contribute to enhance the actions' outcome.
Contribution to the monitoring and implementation, standardisation of the EU-Rail Programme	<p>The action resulting from this topic is identified as a “flagship project” expected to perform, by the completion of the research and innovation lifecycle, “large scale demonstrations”, in the meaning of Council Regulation (EU) 2021/2085. Hence, the action is a key contributor to the achievement of the objectives identified in the Master Plan⁷⁹ as further detailed in the Multi-Annual Work Programme⁸⁰.</p> <p>In this respect, applicants are expected to deliver relevant information (data, results, etc.) as mutually agreed, to the JU and the Linked Project[s] to contribute to the advancement of the Innovation and System Pillars⁸¹ activities, as well as in view of the development and implementation of EU policy and legislation (including Technical Specifications for Interoperability and Common Safety Methods) and the development of European standards. As specified in section 2.3.3.2 of the AWP 2022, and to facilitate contributions to European or international standards, the EU-Rail grant agreements will include an additional information obligation related to standards. Beneficiaries must inform the EU-Rail JU (up to four years after the end of the action) if the results can be reasonably expected to contribute to European or international standards.</p>

⁷⁹ Master Plan available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

⁸⁰ MAWP available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

⁸¹ Refer to the Multi-Annual Work Programme available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

	<p>As part of its internal control and management framework, the JU will perform a of reviews and maturity checkpoints to assess the overall progress against the project plan and against the performance and TRL targets. Depending on the outcome of these reviews and maturity checkpoints(s), the scope of the project may be revised and/or funding reduced in accordance with the provisions of the relevant grant agreement. Mitigation actions may be requested by the JU as condition for continued funding.</p> <p>The proposal shall consider the necessary resources – FTE and/or other – to ensure the monitoring of the “Flagship Project” via regular reporting, reporting of data for the Programme KPIs, etc.. A EU-Rail Governance and Process Handbook is available here : https://shift2rail.org/participate/</p>
Linked Projects	<p>As specified in section 2.3.3.2 of the AWP 2022, in order to facilitate the contribution to the achievement of the EU-Rail JU objectives, the options regarding 'linked actions' of the EU-Rail Model Grant Agreement and the provisions therein, is enabled in the corresponding EU-Rail JU Grant Agreements.</p> <p>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:</p> <ul style="list-style-type: none"> • HORIZON-ER-JU -2022-FA1-01: Network management planning and control & Mobility Management in a multimodal environment and Digital Enablers • HORIZON-ER-JU -2022-FA2-01: Digital & Automatic up to Automated Train Operations • HORIZON-ER-JU -2022-FA3-01: Intelligent & Integrated asset management • HORIZON-ER-JU -2022-FA5-01: Sustainable Competitive Digital Green Rail Freight Services • HORIZON-ER-JU -2022-FA6-01: Regional rail services / Innovative rail services to revitalise capillary lines <p>Please note that the list non-exhaustive as additional Linked Projects may follow at a later stage of the programme implementation to complement the activity.</p>
Funding of only one project per topic	EU-Rail JU may award up to one project with funding depending on the outcome of the evaluation and the complementarity of the proposed actions.
Retroactive starting date of the grant	The starting date of grants awarded under this topic may be as of the submission date of the application. Applicants must justify the need for a retroactive starting date in their application. Costs incurred from the starting date of the action may be considered eligible.
Lump Sum grant	Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025). [[This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon

	Europe, under ‘Simplified costs decisions’ or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/ls-decision_he_en.pdf]].
Lower funding rate	The funding rate of the action is 60% of the eligible costs to achieve the leverage effect established in the SBA. Each Consortia may decide internally different funding rates in line with the provisions of Article 34 of Horizon Europe nevertheless complying with the overall funding rate of 60%.
Award criteria additional details	The award criteria included in the General Annexes of the Horizon Europe – Work Programme 2021 – 2022 are complemented with additional criteria as specified in Annexe 8 this Work Programme.
Additional dissemination obligations	In addition, as specified in section 2.3.3.2 of the AWP 2022, and to facilitate contributions to considering the key contributing role of this topic, in designing the dissemination and communication activities, the proposal shall consider that the “Flagship Project” will be part of the overall EU-Rail Programme and the planning of key events – demonstrations, participations to fair, etc. – will be coordinated at Programme level and by the “Stakeholder Relations and Dissemination” structure of the JU.

Expected Outcome:

Building upon the work achieved in the S2R Programme and other research and innovation, the Flagship Project stemming from this topic should deliver solutions for the holistic approach to:

- Energy and equivalent CO₂ savings in the rail system, covering:
 - Developments oriented towards a more integrated and standardised Rail Power Smart Grid, integrating greener energies⁸², cutting peak of energy consumption and allowing for a better control, and management.
 - Developments oriented towards a better energy management not only at station level but also providing more intelligent and integrated control systems and allowing for a larger energy flexibility and resilience of the Electrical Smart Grid.
- Circular, sustainable solutions contributing to a resilient rail, covering:
 - Technologies, systems and materials for a more sustainable, less resource-intensive and extreme hazard resilient by design (including climate change related issues) of railway infrastructure/assets and rolling stocks, oriented towards the whole life cycle of the assets.
 - Guidelines for the design/rehabilitation of modular stations according to size and uses oriented towards the reduction of the carbon footprint for the whole life cycle.
- A healthier, safer and more attractive railway system, covering:
 - HVAC⁸³ at the vehicle level with improved management of air flow and integration of health management measures in the rolling stock, for a European deployable solution.

⁸² Study on the use of Fuel Cells and hydrogen in the railway environment, available here: https://shift2rail.org/wp-content/uploads/2019/05/Study-on-the-use-of-fuel-cells-and-hydrogen-in-the-railway-environment_final.pdf

⁸³ Results from Shift2Rail activities should be taken into account: public deliverable in PIVOT2 Project available here: https://projects.shift2rail.org/s2r_ip1_n.aspx?p=pivot2 (D18.4 Fundamental work on HVAC)

- Passenger flow management integrating health and safety measures.
- Industrial standards for easing the quick adaptation of interiors by modularity with the integration of bio-sourced materials and circularity of the assets.

The Flagship Project stemming from this topic should deliver, by 2025, innovative and resilient solutions to be demonstrated by:

- Alternative energy solutions for the rolling stock⁸⁴ at TRL6, covering:
 - High performances Batteries Electric Multi-Unit (BEMU) train (reaching TRL6/7);
 - Hydrogen hybrid trains with test of heavy-duty inspection vehicle and loco for freight-passengers ;
 - Sub-urban catenary trains with on board Energy Storage Systems (ESS);
 - Auto adaptive train energy consumption to various services situations;
- A holistic approach to energy in rail infrastructure (design, production, use and intelligent management), at TRL6, covering:
 - Rail Power Smart Grid in different systems as well as the integration of energy storage⁸⁴ solutions;
 - Application of solutions for the production, storage and refuelling of hydrogen for railway vehicles on the example of a prototype refuelling station⁸⁵;
- Sustainability and resilience of the rail system in a holistic approach to asset management, delivering more value:
 - Development of solutions and models for the reduction of noise and vibrations from railway infrastructure and rolling stock⁸⁶ and to predict the effect of degradation, of maintenance and of noise perception (TRL6) as well as ensuring resilience to external risks, such as climate change;
- Improvement of electro-mechanical components and sub-systems for the rolling stock, at TRL6, covering:
 - Technological solutions for the migration to the airless train: Electro-mechanical braking system⁸⁷ and novel electro-mechanical pantograph and suspensions;
 - Optimised motors and gearboxes, high performance bogies, suspensions and new materials;
 - Eco-friendly HVAC system technologies;
 - Aerodynamic certification with experimental and numerical methods;
- Healthier and safer rail system, covering:
 - Simulation tools for improving the air quality in trains, stations and tunnels (reaching TRL7);
- Attractiveness, at TRL5-6, covering:

⁸⁴ The action to be funded under Destination 4 shall foresee a common activity/task related to the capturing of specific requirements stemming from the action to be funded within the Clean Hydrogen JU, in relation to hydrogen solutions, and the partnership BATT4EU concerning batteries

⁸⁵ The action to be funded under Destination 4 shall foresee a common activity/task related to the capturing of specific requirements stemming from the action to be funded within the Clean Hydrogen JU, in relation to hydrogen solutions, and the partnership BATT4EU concerning batteries

⁸⁶ Results from Shift2Rail activities should be taken into account: public deliverables of TRANSIT Project available here: https://projects.shift2rail.org/s2r_ipcc_n.aspx?p=S2R_TRANSIT (Deliverables 2.1 and 3.1)

⁸⁷ Results from Shift2Rail activities should be taken into account: public deliverables of PIVOT Project available here: https://projects.shift2rail.org/s2r_ip1_n.aspx?p=pivot (Deliverables 5.1 and D5.8); PIVOT2 Project available here: https://projects.shift2rail.org/s2r_ip1_n.aspx?p=pivot2 (Deliverable 9.5); and CONNECTA Project available here: https://projects.shift2rail.org/s2r_ip1_n.aspx?p=CONNECTA (Deliverables 5.1, 5.2, 5.3 and 5.5)

- Modular rolling stock interiors providing new design and new architectures (including drivers' cabin), respecting PRM requirements and enhancing accessibility where possible.

In addition of the above, the proposal shall cover important preparatory works needs to be launched for the future set of demonstration foreseen in the Multi- Annual Work Programme in view of the evolutions of the solutions up to TRL 8, and where possible 9:

- integration of technical enablers for high performances BEMU trains to enhance standardised and interoperable batteries charging interfaces and data protocol to ensure cost efficiency ;
- scalability of H2 refuelling station solutions and energy storage applications;
- airless train components' evolution and technologies used for the reduction of noise, weight and energy consumption
- preparation and/or simulation of the integrated demonstration in real environment of modular rolling stock.

The action to be funded under this Destination also needs to be provide the following necessary elements for the demonstrations under the action to be funded under the **Destination 6, Regional rail services / Innovative rail services to revitalise capillary lines** to be delivered for 2025 demonstrations: enablers 1, 2, 3 and 4 as described under the Scope section of this Destination. In addition of the above, the proposal shall cover important preparatory works needs to be launched for the future set of FA6 demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions, linked with the same enablers at higher TRL.

The action to be funded under this Destination also needs to be provide the following necessary elements for the demonstrations under the action to be funded under the **Destination 1, Network management planning and control & Mobility Management in a multimodal environment** to be delivered for 2025 demonstrations: enablers 4 and 5 as described under the Scope section of this Destination, in addition to providing DAS/C-DAS and energy management experts input for the optimization methods for capacity efficiency and energy saving. In addition of the above, the proposal shall cover important preparatory works needs to be launched for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions, linked with the same enablers at higher TRL.

Scope:

The Flagship Project stemming from this topic should develop the following capabilities:

Alternative energy solutions for the rolling stock

Development, validation and demonstration of traction system components, including related innovative and standardised functions, to improve technical, environmental, circular economy and LCC KPIs. To demonstrate the feasibility of the results of the innovation, the technical enabler will be applied in static test bench and real demonstrators of:

- Enabler 1: Trains with on-board Energy Storage Systems. High performance and high efficient Batteries Electric Multi-Unit (BEMU) trains with long autonomy (80km baseline and over 200 km targeted) and sub-urban catenary trains with high level of braking energy recovery and energy autonomy (TRL 6/7 to be achieved in 2026)
- Enabler 2: Hydrogen hybrid trains: infrastructure inspection/maintenance heavy duty vehicle and loco for freight-passengers at TRL 5/6 (powered with gas H2 or liquid H2)

Holistic approach to energy management in the railway system

The increased use of renewable energy sources (RES), energy storage devices and the smart energy management will improve the global mobility decarbonization and the energy efficiency of the railway system. Within this Destination, this approach will be done through:

- Enabler 3: The application of solutions for the production, storage and refuelling of hydrogen for railway vehicles on the example of a prototype refuelling station. Development of a standard refuelling interface using algorithms to ensure optimum time and safety of the process as well as provide scalability and future growth of the refuelling station depending on the demand for hydrogen with TRL6 targeted in 2025.
- Enabler 4: Integration of various sources in different systems (e.g. 25kV AC, 1,5/3kV DC), of renewable energy, energy harvesting technologies, superconducting, breaking energy recovery, etc, as well as the integration of energy storage with TRL6 targeted in 2025.
- Enabler 5: Solutions for the optimal energy management in the whole power system, covering traction and non-traction demand including stations as energy hubs and integrated in a smart grid under the market rules and targeting at TRL5 in 2025.

Sustainability and resilience of the rail system to deliver added value on asset management

This Destination aims to provide solutions to foster environmental advantages of rail, reduce nuisances and addressing resilience on the whole life cycle through:

- Enabler 6: Adaptation to climate change with the development of a tool on European climate variables usable for railway assets, considering risk assessment reports and the benchmark of existing solutions to accelerate the lowering of environmental footprint targeting TRL5 in 2025 to implement adaptation strategies.
- Enabler 7: Development of noise indicators, simulation tools and development of optimised components and optimised maintenance regimes for noise and vibrations, aiming at TRL6 in 2025, taking also into account different climate conditions in the EU.
- Enabler 8: Methodologies and guidelines for the optimal design/rehabilitation of station layout including modularity oriented towards carbon footprint reduction to be validated at TRL5/6 in 2025.
- Enabler 9: Development of tools and indicators to promote eco-design, assess environmental performance improvements and ensure standardized reporting of the environmental impacts of the rail sector at TRL5 in 2025.

Improvement of electro-mechanical components and sub-systems for the rolling stock

The technological solutions for the migration to the airless train will require high performance bogies, gearboxes, suspensions, and materials. This destination will achieve those improvements by:

- Enabler 10: Developing and introduce to the market electro-mechanical braking system, pantograph and suspensions while targeting energy savings on the involved subsystems and reduce associated maintenance costs by reaching TRL6 for 2025 and prepare for later evolutions.
- Enabler 11: Introducing optimised motors and gearboxes, high performance bogies, suspensions and new materials following circular economy principles and reaching TRL6 in 2025.

- Enabler 12: Delivering alternative technologies to replace hydrofluorocarbon refrigerants by HVAC system using green refrigerants or new cooling technologies with reduced energy consumption and targeting TRL6 in 2025.
- Enabler 13: Introducing enhanced experimental and numerical methods at TRL6 on aerodynamic certifications by 2025.

Healthier and safer rail system

The demonstration of novel systems and technologies to include enhancing the air quality by air purification and air distribution while addressing the thermal comfort and air quality (virus, bacteria, volatile organic compounds and fine particles) to guarantee a platform independent approach by:

- Enabler 14: Specific sub-demonstrators to be set-up, each of them contributing to the overall goal of the demonstration of a healthier environment in the rail vehicle, for both new designs of future trains and refurbishment of existing trains and targeting TRL7 in 2025.

Attractiveness

This destination is expected to develop rolling stock interiors designed by modularity, plug and play fixation systems by innovative low-tech, circular design and comfort aspects, as well as to develop new architectures for driver's cabin to reach TRL5-6 in 2025. Within this Destination, the demonstrations will be supported on:

- Enabler 156: The facilitation of on-demand comfort for users such as access, lighting, thermal and acoustic conditions as well as with new architectures to increase passenger capacity and target TRL5-6 in 2025.
- Enabler 16: The facilitation to adapt rolling stock with refurbishment and innovative concepts to support the increase of capacity of the rolling stock targeting TRL5-6 in 2025 and prepare for later evolutions.

Developments on all those 16 enablers should also cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions.

The action shall actively contribute to measure and monitor the specific quantitative KPIs defined in the Destination description above, including its contribution to the Europe's Rail Master Plan impacts.

The action shall actively contribute to the EU-Rail standardisation rolling development plans wherever relevant. Similarly, the action shall contribute to the development and implementation of EU policy and legislation including Technical Specifications for Interoperability and Common Safety Methods, as well as to publications of the System Pillar.

Collaboration work required with other FAs

The action to be funded under Destination 4 shall foresee a common activity/task related to capturing specific requirements and review of system specifications relevant to the actions to be funded under Destination 1 and Destination 6.

Interaction with the System Pillar

The System Pillar aims to guide, support and secure the work of the Innovation Pillar (i.e. to ensure that research is targeted on commonly agreed and shared customer requirements and operational needs, compatible and aligned to the system architecture), and the Innovation Pillar will impact the scope of the System Pillar where new technologies or processes mean that innovations can drive a change in approach, as well as delivering detailed specifications and requirements.

In this respect, the necessary resources would have to be dedicated to areas linked to System Pillar conceptual and architecture works – particularly addressing specification development (the interaction is illustrated in the System Pillar – Innovation Pillar interaction note (Annex VI of this Work Programme). The alignment of the activities will primarily take place during the Grant Preparation Phase and ramp up phase of the awarded proposal, and there will be continued interaction through the life of the project.

Gender dimension

In this topic the integration of the gender dimension (sex and gender analysis) in research and innovation content is not a mandatory requirement.

5. DESTINATION 5 – Sustainable Competitive Digital Green Rail Freight Services

DESTINATION 5 – description (possibly included in the Expected Outcome in the Funding Portal)

The objective of this Destination is to make rail freight more attractive through better services to the European supply chain by the following threefold : Increasing capacity in a smart way for all types of rail freight transport(e.g. with Digital Automatic Coupler (DAC) and other technological and operational solutions), Improving cross-border operation (cross border implies an important share of freight traffic and it expected to grow) and finally a better multimodal service offering. In addition to all these, this destination aims to contribute if necessary in the delivery of harmonization by means of contributing on the definition of European Standards.

Those objectives should be addressed aiming to deliver solutions in the following areas:

- **Full digital freight train operations** enabled by key technologies for transforming the European Rail Freight sector which will increase productivity (time and cost reduction), efficiency (through process automation) and service quality, all of that leading to an increase of competitiveness. Together with a “smart” increase of capacity, more freight traffic can be shifted to the European rail system, significantly contributing to the EU Green Deal. The development of innovative freight assets (e.g. innovative freight wagons, last mile solutions, terminals) allow to further improve the competitiveness of rail freight by reducing LCC⁸⁸, operational costs and also increasing automation.
- A **seamless rail freight** with a significantly reduced average transportation time based on an agile, interoperable and open environment within integrated and harmonized European mobility networks which interacts with other businesses; an environment in which companies can optimize their operations; for railway undertakings and intermodal operators, this results into higher productivity, better capacity utilization, improved planning possibilities and, through the reduction of cross-border barriers and multimodality, faster transport handling, altogether resulting into higher reliability. In addition, comprehensive multimodal and transparent customer information in combination with easy booking and managing functions, lead to an increase in customer satisfaction and easier access to rail-based services. Being based on harmonized European data this leads to higher predictability and planning possibilities.

The selected proposal for funding under this Destination will be a Flagship Project of Europe’s Rail JU with significant expected impacts, which require an integrated sector systemic approach. Proposals, should therefore set out a credible pathway to contributing to all of the following expected impacts as described in the Europe Rail JU Master Plan.

⁸⁸ Life Cycle Costs LCC



Meeting
evolving
customer
requirements



Improved EU rail
supply industry
competitiveness



More
sustainable
and resilient
transport



Reinforced
role for rail in
European
transport and
mobility



Improved
performance
and capacity



Reduced
costs

Proposals under this Destination should set appropriate monitoring and demonstration activities to measure the following KPIs:

In the field of European full digital freight train operations

- Decrease train formation/decomposition (shunting/coupling/uncoupling) time:
 - Expected time reduction targeting 40-50%.
- Decrease train preparation/ departure process time:
 - Expected time reduction targeting 40-70%.
- Demonstrate increased average train length [m] up to maximum length in existing infrastructure limitations or higher loads:
 - Train length increased up to 1.500 m.

In the field of seamless rail freight

- Reduce average transportation time on reference corridor
 - Average transportation lead time reduced targeting towards the MAWP objective 10-20%.
- Reduce operational dwell time at borders and other handover points:
 - Dwell time reduced targeting towards the MAWP objective 50%.
- Reduce the number of additional non-added value operational stops (limiting also the energy consumption):
 - Reduced number of operational stops targeting 20%.
- Reduce handling/response time for ad-hoc cross-border path requests
 - Reduced time by targeting towards the MAWP objective 70%.
- Reduce handling/response time for connected comprehensive intermodal offers
 - Reduced response time by at least 30%, targeting the objective 50% as stated in MAWP 50%.
- Reduced energy consumption and reduced footprint through less stops at borders
 - Reduced energy consumption by a minimum of 6% targeting towards the overall MAWP objective of 10%.

The following call in this work programme contribute to this Destination:

Call	Budgets (EUR million)			Deadline
	2021/2022	2023	2024	
HORIZON-ER-JU-2022-01	23.5	12.8	4.3	23 June 2022
Minimum overall indicative budget	40.6			

Call: HORIZON-ER-JU-2022-01**Conditions for the Call**Indicative budget(s)

Topics	Type of Action	Budgets (EUR million)			Expected EU contribution per project (EUR million) ⁸⁹	Number of projects expected to be funded
		2021/2022	2023	2024		
	Opening: 10 March 2022 Deadline(s): 23 June 2022					
HORIZON-ER-JU-2022-FA5-01	IA	23.5	12.8	4.3	40.6	1
Overall indicative budget		40.6				

General conditions relating to this call	
<i>Admissibility conditions</i>	The conditions are described in part A of the General Annexes to the Horizon Europe Work Programme 2021-2022
<i>Eligibility conditions</i>	The conditions are described in part B of the General Annexes to the Horizon Europe Work Programme 2021-2022
<i>Financial and operational capacity and exclusion</i>	The criteria are described in part C of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Award criteria</i>	The criteria are described in part D of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Documents</i>	The documents are described in part E of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Procedure</i>	The procedure is described in part F of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Legal and financial set-up of the Grant Agreements</i>	The rules are described in part G of the General Annexes to the Horizon Europe Work Programme 2021-2022.

⁸⁹ Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

Proposals are invited against the following topic(s):

HORIZON-ER-JU-2022-FA5-01: Sustainable Competitive Digital Green Rail Freight Services

Specific Conditions	
Expected EU contribution per project	EU-Rail estimates that an EU contribution of EUR 40.6 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	<p>The total indicative budget for the topic is EUR 40.6 million.</p> <p>Applicant Private⁹⁰ Members of the EU-Rail JU part of consortia responding to this topic should provide in-kind contributions to additional activities to be declared via the template model available on the F&T portal. The amount of total in-kind contributions (i.e. in-kind contributions for operational activities and in-kind contributions for additional activities) should be no less than 1.263⁹¹ times the funding request, in aggregate, of these applicant Private Members. Any discrepancy shall be well and duly justified.</p> <p>In this respect, the grant agreements will set, in principle, annual deliverable on in-kind contributions for the projects selected under this topic, as well as mandatory reporting requirements, for those applicants who are Private Members of the EU-Rail JU.</p>
Indicative project duration	48 months.
Type of Action	Innovation Action
Technology Readiness Level	Activities are expected to achieve a minimum between TRL 5 and TRL 8/9, depending on the enabler addressed, or higher by the end of the project – see General Annex B for a guide to the TRL definitions and criteria to be used.
Admissibility conditions	Regarding admissibility conditions and related requirements, part A of the Horizon Europe Work Programme 2021-2022 General Annexes applies with the following exception: the limit for a full Innovation Action application is set to 120 pages.
Special skills and/or capabilities expected from the Applicant(s)	<p>Applicants shall ensure that their proposals and consortium reflect the aggregated expertise to perform the activities and achieve the objectives set by the Destination:</p> <ul style="list-style-type: none"> • Expertise from rail infrastructure managers and railway undertakings, which should allow <ul style="list-style-type: none"> – defining main challenges, use cases and functional needs, – specifying, prioritizing and clustering demonstrators to ensure that researched innovative processes, operational and technological solutions are covered,

⁹⁰ As defined in Article 2(5) of Council Regulation (EU) 2021/2085.

⁹¹ In order to support a leverage factor of no less than the ratio between the contribution from members other than the Union and the Union financial contribution, as on the basis of Articles 88 and 89 of Council Regulation (EU) 2021/2085.

	<ul style="list-style-type: none"> – hosting the demonstrations and providing test trains/facilities, – providing data structures and content as well as processes, e.g. certification which can be subject for digitalisation. • Expertise from rail suppliers (system integrators, manufacturers and/or technology providers), which should allow, jointly, <ul style="list-style-type: none"> – proposing operational and technological innovative solutions to identified use cases and functional needs, – identifying the technical requirements and interface specifications, aligned with the System Pillar architecture, – designing, developing, prototyping and delivering innovative operational & technological solutions and systems to be integrated within the demonstrations, depending on the specific target TRL level. • Expertise from research institutes and academia, which should allow <ul style="list-style-type: none"> – planning, developing, studying, testing and evaluating solutions, systems and demonstrators together with the previous categories of expertise, – supporting any possible scientific or methodological issues that may arise during the performance of the action – contributing to other aspects of the innovation cycle, as well as to the procedural aspects for validation, certification, etc. • Complementary expertise from other sectors and parties, with particular attention to SMEs and Start-ups, which may contribute to enhance the actions' outcome.
Contribution to the monitoring and implementation, standardisation of the EU-Rail Programme	<p>The action resulting from this topic is identified as a “flagship project” expected to perform, by the completion of the research and innovation lifecycle, “large scale demonstrations”, in the meaning of Council Regulation (EU) 2021/2085. Hence, the action is a key contributor to the achievement of the objectives identified in the Master Plan⁹² as further detailed in the Multi-Annual Work Programme⁹³.</p> <p>In this respect, applicants are expected to deliver relevant information (data, results, etc.) as mutually agreed, to the JU and the Linked Project[s] to contribute to the advancement of the Innovation and System Pillars⁹⁴ activities, as well as in view of the development and implementation of EU policy and legislation (including Technical Specifications for Interoperability and Common Safety Methods) and the development of European standards. As specified in section 2.3.3.2 of the AWP 2022, and to facilitate contributions to European or international standards, the EU-Rail grant agreements will include an additional information obligation related to standards. Beneficiaries must inform the EU-Rail JU (up to four years after the end of the action) if the results can be reasonably expected to contribute to European or international standards.</p> <p>As part of its internal control and management framework, the JU will perform a of reviews and maturity checkpoints to assess the overall progress against the project plan and against the performance and TRL targets. Depending on the outcome of these reviews and maturity checkpoints(s), the scope of the project</p>

⁹² Master Plan available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

⁹³ MAWP available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

⁹⁴ Refer to the Multi-Annual Work Programme available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

	<p>may be revised and/or funding reduced in accordance with the provisions of the relevant grant agreement. Mitigation actions may be requested by the JU as condition for continued funding.</p> <p>The proposal shall consider the necessary resources – FTE and/or other – to ensure the monitoring of the “Flagship Project” via regular reporting, reporting of data for the Programme KPIs, etc.. A EU-Rail Governance and Process Handbook is available here : https://shift2rail.org/participate/</p>
Linked Projects	<p>As specified in section 2.3.3.2 of the AWP 2022, in order to facilitate the contribution to the achievement of the EU-Rail JU objectives, the options regarding 'linked actions' of the EU-Rail Model Grant Agreement and the provisions therein, is enabled in the corresponding EU-Rail JU Grant Agreements.</p> <p>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:</p> <ul style="list-style-type: none"> • HORIZON-ER-JU -2022-FA1-01: Network management planning and control & Mobility Management in a multimodal environment and Digital Enablers • HORIZON-ER-JU -2022-FA2-01: Digital & Automatic up to Automated Train Operations • HORIZON-ER-JU -2022-FA3-01: Intelligent & Integrated asset management • HORIZON-ER-JU -2022-FA4-01: A sustainable and green rail system • HORIZON-ER-JU -2022-FA6-01: Regional rail services / Innovative rail services to revitalise capillary lines <p>Please note that the list non-exhaustive as additional Linked Projects may follow at a later stage of the programme implementation to complement the activity.</p>
Funding of only one project per topic	EU-Rail JU may award up to one project with funding depending on the outcome of the evaluation and the complementarity of the proposed actions.
Retroactive starting date of the grant	The starting date of grants awarded under this topic may be as of the submission date of the application. Applicants must justify the need for a retroactive starting date in their application. Costs incurred from the starting date of the action may be considered eligible.
Lump Sum grant	Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025). [[This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under ‘Simplified costs decisions’ or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/lump-sum-decision_he_en.pdf]].
Lower funding rate	The funding rate of the action is 60% of the eligible costs to achieve the leverage effect established in the SBA. Each Consortia may decide internally different

	funding rates in line with the provisions of Article 34 of Horizon Europe nevertheless complying with the overall funding rate of 60%.
Award criteria additional details	The award criteria included in the General Annexes of the Horizon Europe – Work Programme 2021 – 2022 are complemented with additional criteria as specified in Annexe 8 this Work Programme.
Additional dissemination obligations	In addition, as specified in section 2.3.3.2 of the AWP 2022, and to facilitate contributions to considering the key contributing role of this topic, in designing the dissemination and communication activities, the proposal shall consider that the “Flagship Project” will be part of the overall EU-Rail Programme and the planning of key events – demonstrations, participations to fair, etc. – will be coordinated at Programme level and by the “Stakeholder Relations and Dissemination” structure of the JU.

Expected Outcome:

Building upon the results of S2R IP5⁹⁵ and European DAC Delivery Programme (EDDP)⁹⁶ in particular, and other rail research and innovation activities, the Flagship Project stemming from this topic is expected to contribute to Europe’s Rail Programme addressing the two areas described in the previous Destination 5 section, more in particular addressing two workstreams :

1. Work Stream WS1 Full digital Freight Train Operations with DAC as enabler for full digital freight train operation;
2. Work Stream WS2 Seamless Freight: with easy access and reliable (intermodal) transport service offering digital solutions.

For **WS1** this destination should deliver by 2025 the following demonstrators:

- **European full digital freight train operations: (TRL 8-9)** Large-scale demonstrator showing full digital freight train operations based on DAC Type 4⁹⁷ (incl. energy supply & data/communication solution and Type 5 upgradability, equipping existing wagons with DAC technology and existing locomotives with hybrid DAC) in different regions with several train sets under real operational conditions including technical enablers described in scope section.
- **European full digital freight train operations: (TRL 7)** Proposals are expected to deliver a second demonstrator with a lower TRL level for technical solutions for parking brake system, digital wagon inspection (including rolling stock and infrastructure assets), DAC based telematic applications for customer requirements (goods monitoring) / for asset performance management /CBM / for safety related applications, distributed power system and electro-pneumatic brake.

⁹⁵ Results from Shift2Rail activities should be taken into account, please see FR8RAIL II (https://projects.shift2rail.org/s2r_ip5_n.aspx?p=FR8RAIL%20ii) D1.2-FR82 Automatic coupling and wagon design spec

⁹⁶ <https://shift2rail.org/european-dac-delivery-programme/>

⁹⁷ DAC Types definition can be found here <https://shift2rail.org/european-dac-delivery-programme/>

- **European full digital freight train operations: (TRL 8 – some functionalities at lower TRL, see enabler section)** Demonstration of Yard automation equipment, wagon identity system allowing automated shunting, video gates and way side check points with visual recognition and AI tools for yard automation.

Demonstrators shall focus on full functionality (added value for the sector respecting/meeting customer needs), safe system integration, interoperability, harmonized (cross-border) operation.

The return on experience of the demonstrators shall pave the way for preparing an European-wide DAC roll-out and finalization of the DAC standardisation with the aim to build up robustness various TSI revisions. This will enable necessary safety analysis or safe system integration followed by authorisation prerequisite for deployment.

In addition of the above, the proposal shall cover important preparatory works to be launched for the future set of demonstration foreseen in the Multi- Annual Work Programme in view of the evolutions of the solutions

- Train integrity + train length determination
- Rail freight operation with ATO Low-weight, low-energy, low-noise, high performing wagon concepts,
- Self-propelled wagon concepts
- Automated/autonomous loading/unloading technologies for last mile distribution
- Fully automated shunting loco movements (GoA4)

For **WS2** this destination should deliver by 2025 at least the following:

Seamless freight corridor TRL 5-8

The comprehensive innovations for planning and operation of cross-border freight trains should be demonstrated on (parts of) two European corridors. The seamless interaction across borders and involved stakeholders should be shown by freight specific pilot implementations of key enablers for improved cross-border timetable planning, management and path ordering systems taking into account also last mile service, as well as for real-time interaction between various TMS (including yards/terminals) coming from destination 1. Further enabler which should be demonstrated will be connected to dynamic yard/terminal planning and management. The demonstrations shall include the real-time data gathering and processing of influencing data, as well as solutions for better prediction and management. This demonstrator should include technologies for standardized European Railway checkpoints at borders or other operational stop points, replacing manual process by digitalization and automation, using innovative technologies and processes. The demonstrator will include Integrating and connecting the last mile (accession lines/shunting/yards/ terminals) slot planning directly or via interfaces. This will have to be connected with other supporting implementations like certified translation tools or harmonized processes.

Seamless customer freight TRL5-8

The seamless planning, management and booking of multimodal rail-based transport integrating multi-actors, should be demonstrated by combining the key enablers to an innovative open system, which will simplify the way of organizing transport and integrating rail in modern supply chains. Based on increased data quality and availability on one side and

improved routing engines on the other side it should be demonstrated how transport planning⁹⁸ will get more responsive to changing demand, disruptions and customer requirements. This demonstrator will ease end customers to interface with rail. In addition dynamic TMS stemming from call the flagship project from Destination 1 shall be incorporated in connection with dynamic dispatching tools which shall be key for the optimal automation of yards and last mile operations⁹⁹.

In addition of the above, the proposal shall cover important preparatory works needs to be launched for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions mentioned above, which then shall be extended by additional functions, extended scope and higher TRL levels.

The action to be funded under this Destination shall also provide technical and operational requirements (and all necessary elements) for the developments of “Destination 1” enablers 1, 2, 4, 6, 8, 10 under the action to be funded under the **Destination 1 Network management planning and control & Mobility Management in a multimodal environment and Digital Enablers**.

The action to be funded under this Destination shall also provide technical and operational requirements (and all necessary elements) for the for the developments of “Destination 2” enablers 1, 3 and 4 to be developed under the action to be funded under the **Destination 2 – Digital & Automated up to Autonomous Train Operations**.

The action to be funded under this Destination also shall provide technical and operational requirements (and all necessary elements) for the development of CBM methodologies and algorithms under the action to be funded under the **Destination 3 - Intelligent & Integrated asset management**.

Scope:

The Flagship Project stemming from this topic should develop the following capabilities:

Capabilities for improving European full digital freight train operations

- Enabler 1: Development of an EU-harmonized DAC, plus the necessary freight consist backbone system including a solution for both the energy supply as well as data/communication (setting the right conditions towards modular -standard interfaces- expected to be scalable, of plug & play integration , etc. solution). As needed by the demonstrator the enabler must be able to drive complete train sets and the DAC shall be upgradable to Type 5. There is also the need to develop a coupler solution for locomotives and a type 5 coupler. **(TRL 8 by 2025)**

⁹⁸ Results from Shift2Rail activities should be taken into account, see S2R IP5 ARCC (https://projects.shift2rail.org/s2r_ip5_n.aspx?project_id=0ce52d3b-d1c7-4ee8-ab54-1711f7c6f807) D3.1 – Improved methodology for timetable planning

⁹⁹ Results from Shift2Rail activities should be taken into account, see S2R IP5 OPTIYARD (https://projects.shift2rail.org/s2r_ip5_n.aspx?p=OPTIYARD) D5.2 Yard optimization algorithm_network decision-support tool

- Enabler 2: Developing a train composition detection/management system, automated/automatic brake test system, on asset side DAC wagon retrofitting solutions. **(TRL 8 by 2025)**
- Enabler 3: Automated parking brake system, digital wagon inspection, DAC based telematics applications, distributed power system, electro-pneumatic brake **(TRL 7 by 2025)** and cover important preparatory works incl. train dynamics with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions

Capabilities for increasing automation in shunting operations

- Enabler 4: Development of systems and solutions for basic autonomous shunting operations. Development of solutions for yard automation including digitalization that enable automated train composition and dispatching (Automated Shunting Operations), including necessary wagon identity system for automated shunting **(TRL5-8 by 2025)** and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi-annual Work programme in view of the evolutions of the solutions
- Enabler 5: Integrative deployment of video gates, way side check points, visual recognition methodologies and AI-Tools for yard automation **(TRL 8 by 2025)**
- Enabler 6: Achieving expected consolidation of the expected new freight capabilities, providing requirements and giving feedback to Destination 2 for new automation technology solutions for the automated driving and decision-making as well as automating functions, such as train preparation and basic automatic yard shunting.

Capabilities for DAC based wagon concepts incl. multi-modal transport applications

- Enabler 7: Developing DAC based wagon concepts incl. multi-modal transport applications (retrofitting needs for combined traffic T3000 kind of wagons) **(TRL 8 by 2025)** and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions

Capabilities for Seamless Freight Corridor

- Enabler 8: Specify and deliver freight specific requirements for integrated cross-border timetable planning, management and path ordering systems (including requirements for covering also the last mile) suitable for development in destination 1
- Enabler 9: Setting up the respective models and systems to test and demonstrate the destination 1 developments for integrated timetable planning on selected part of a European corridor **[TRL5-8 by 2025]** and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions
- Enabler 10: Develop dynamic yard/terminal management systems and test their integration with dynamic TMS based on agreed interfaces– that will specified among destination 1 and

the TMS development will come from destination 1 **[TRL 6 by 2025]** and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi-annual Work programme in view of the evolutions of the solutions

- Enabler 11: Specify and develop intermodal monitoring and prediction systems, which shall work in combination with dynamic TMS and other resource management systems using AI based models, accuracy and computational learning functions **[TRL7 by 2025]** and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions
- Enabler 12: Specify and develop Railway Checkpoints that will automate Freight Train Transfer Inspections at borders or other operational stop points, digitalising and automating processes through innovative sensors, specialised adapted video gates and handheld devices, in combination with harmonized procedures and regulation across European rail network and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions
- Enabler 13: Finalise R&I development of certified secured translation tools¹⁰⁰ to enable in combination with multi-country driver licensing and appropriate rostering concepts a harmonised cross-country operation **[TRL7-8 by 2025]** and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions

Capabilities for Seamless Freight Multimodal and Customer

- Enabler 14: Specifications for the development of integrated multimodal transport planning, management and operational systems enabling easy access to rail-base (intermodal) services and dynamic demand responsive service offering, network planning and capacity management based on agreed interfaces with TMS – with Destination 1 - and the specific freight development to support this functionality **[TRL6-8/9 by 2025]**. and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi-annual Work programme in view of the evolutions of the solutions
- Enabler 15: Analysis and coordination of requirements for seamless data exchange / data availability for the various Destination 5 developments and planned demonstrations, taking into account existing/proposed data standards (if applicable) and regulations e.g. TAF TSI. Specification and development of required processes/tools (e.g. interfaces/ converters.) **[TRL 7-8 by 2025]** and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions
- Enabler 16: Analysis and coordination of required technology upgrades of legacy/national systems to be able to provide/consume/process harmonised data from/for international (European) applications/innovations. Development of an implementation plan.

¹⁰⁰ Results from Shift2Rail activities should be taken into account, see S2R Translate for Rail (https://projects.shift2rail.org/s2r_ipx_n.aspx?p=S2R_TRANSLATE4RAIL) D2.1 Guidelines for implementation

The action shall actively contribute to measure and monitor the specific quantitative KPIs defined in the Destination description above, including its contribution to the Europe's Rail Master Plan impacts.

The action shall actively contribute to the EU-Rail standardisation rolling development plans wherever relevant. Similarly, the action shall contribute to the development and implementation of EU policy and legislation including Technical Specifications for Interoperability and Common Safety Methods, as well as to publications of the System Pillar.

Collaboration work required with other FAs

The action to be funded under Destination 5 should foresee developing a deliverable capturing specific requirements described in the Expected scope and relevant for the action to be funded under Destination 1, Destination 2, and Destination 3, suggested to be delivered indicatively by M6.

The action to be funded under Destination 5 shall foresee a common activity/task related to the review of system specifications to be developed by the action to be funded under Destination 1, Destination 2, Destination 3.

The action to be funded under Destination 5 shall foresee a common activity/task related to the Preparatory works on the integration and pilot test(s) of the technical enablers to be provided by the action to be funded under Destination 1, Destination 2, Destination 3 for the demonstration to be carried out in the action to be funded by Destination 1, Destination 2, Destination 3.

Interaction with the System Pillar

The System Pillar aims to guide, support and secure the work of the Innovation Pillar (i.e. to ensure that research is targeted on commonly agreed and shared customer requirements and operational needs, compatible and aligned to the system architecture), and the Innovation Pillar will impact the scope of the System Pillar where new technologies or processes mean that innovations can drive a change in approach, as well as delivering detailed specifications and requirements.

In this respect, the proposal should allocate necessary resources that would be dedicated to areas linked to the System Pillar conceptual and architecture works – particularly addressing specification development (the interaction is illustrated in the System Pillar – Innovation Pillar interaction note (Annex VI of this Work Programme) and to areas linked with the EDDP). The alignment of the activities will primarily take place during the Grant Preparation Phase and ramp up phase of the awarded proposal, and there will be continued, structured and regular interaction through the life of the project.

Gender dimension

In this topic the integration of the gender dimension (sex and gender analysis) in research and innovation content is not a mandatory requirement.

6. DESTINATION 6 – Regional rail services / Innovative rail services to revitalise capillary lines

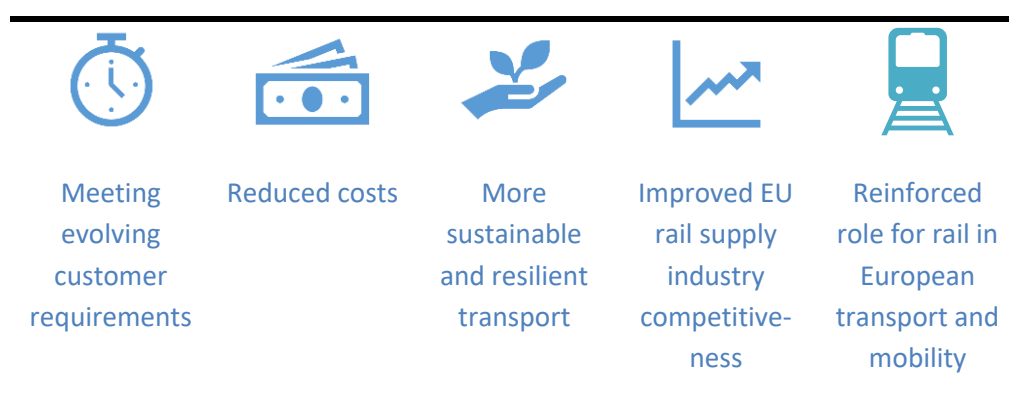
DESTINATION 6 – description (possibly included in the Expected Outcome in the Funding Portal)

Regional railway (lower usage lines or secondary network) plays a crucial role not only in serving Europe's regions but also as feeder lines for passenger and freight traffic for the main/core network. Hence, having an essential function as green transport and connecting other public transport services (e.g. bus) as well as first & last mile services such as car, bike sharing, cycling, walking from railway stations to remote locations. However, these railway lines need to be revitalized or even regenerated to make them economically, socially and environmentally sustainable and meet the current customer needs. The overall objective is to ensure long term viability of regional railways by decreasing the total cost of ownership, in other words, cost per kilometre both in terms of OPEX and CAPEX, while offering a high quality of service and operational safety as well as better customer satisfaction.

These goals are expected to be achieved through a concept tailored to regional railways that includes digitalisation, automation and utilisation of mainstream and emerging technologies for signalling and trackside components, rolling stock and customer information.

The outcome and demonstrated solutions shall not only be applicable for specific lines or regions but be adequately scalable and interoperable to become a European solution. Furthermore, proposed solutions and technologies could be applied to provide a more cost-efficient infrastructure in other settings. In addition standardised solutions for specific regional railways that are not functionally / operationally connected with mainline network might apply or for the purpose of pilot applications with the perspective of a further development for global application.

The selected proposal for funding under this Destination will be a Flagship Project of Europe's Rail with significant expected impacts, which require an integrated sector systemic approach. Proposals, should therefore set out a credible pathway (including an exploitation plan) to contributing to the following expected impacts as described in the Master Plan.



Proposals under this Destination should set appropriate monitoring and demonstration activities to measure the following KPIs:

Regional System Solutions, CCS & Operations and Regional Railway Assets

- Reduced CAPEX of the CCS system, while maintaining or increasing the present safety level:

- Expected decrease by targeting 25%.
- Reduced the CAPEX of radio network and allowing for higher savings due to the utilization of public radio network in low density lines:
 - Expected decrease by targeting 15%.
- Increased system availability due to reduced trackside asset failure and more reliable CCS (Average delay minutes per assets and signalling failures):
 - Expected increase by targeting 10%.
- Reliable cost-effective fail safe on board train integrity, train length detection and train positioning:
 - Increased reliability by targeting 15%,
 - Reduced OPEX and CAPEX by targeting 15%.
- Optimized energy consumption and higher punctuality through ATO over ERTMS targeting GoA4:
 - Expected decrease of energy consumption targeting 10%,
 - Increased punctuality targeting 15%.
- Reduced OPEX costs/km (reduction expected due to trackside asset decrease) for trackside railway assets:
 - Expected reduction of targeting 30%.
- Reduced OPEX costs/km (reduction expected due to trackside asset decrease) for trackside railway assets:
 - Expected reduction of targeting 30%.
- Increased energy efficiency for trackside railway assets (as part of the OPEX saving above, not to be added on top):
 - Expected increase by targeting 15%.

Rolling Stock & Customer Services

- Reduced vehicle CAPEX & OPEX through innovative, modular and lighter design:
 - Targeting 50% reduced CAPEX and OPEX, in a LCC perspective.
- Notwithstanding the previous KPI, passenger vehicles development should aim for step changes in weight reduction and track force reduction, while being tolerant to higher unevenness of the tracks:
 - up to 60% of weight reduction.

The following call(s) in this work programme contribute to this Destination:

Call	Budgets (EUR million)			Deadline
	2021/2022	2023	2024	
HORIZON-ER-JU-2022-01	9.6	5.2	1.7	23 June 2022
Minimum overall indicative budget	16.5			

Call: HORIZON-ER-JU-2022-01**Conditions for the Call**Indicative budget(s)

Topics	Type of Action	Budgets (EUR million)			Expected EU contribution per project (EUR million) ¹⁰¹	Number of projects expected to be funded
		2021/2022	2023	2024		
	Opening: 10 March 2022 Deadline(s): 23 June 2022					
HORIZON-ER-JU-2022-FA6-01	IA	9.6	5.2	1.7	16.5	1
Overall indicative budget		16.5				

General conditions relating to this call	
<i>Admissibility conditions</i>	The conditions are described in part A of the General Annexes to the Horizon Europe Work Programme 2021-2022
<i>Eligibility conditions</i>	The conditions are described in part B of the General Annexes to the Horizon Europe Work Programme 2021-2022
<i>Financial and operational capacity and exclusion</i>	The criteria are described in part C of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Award criteria</i>	The criteria are described in part D of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Documents</i>	The documents are described in part E of the General Annexes to the Horizon Europe Work Programme 2021-2022.
<i>Procedure</i>	The procedure is described in part F of the General Annexes to the Horizon Europe Work Programme 2021-2022.

¹⁰¹ Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

<i>Legal and financial set-up of the Grant Agreements</i>	The rules are described in part G of the General Annexes to the Horizon Europe Work Programme 2021-2022.
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Proposals are invited against the following topic(s):

HORIZON-ER-JU-2022-FA6-01: Regional rail services / Innovative rail services to revitalise capillary lines

Specific Conditions	
Expected EU contribution per project	EU-Rail estimates that an EU contribution of EUR 16.5 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	<p>The total indicative budget for the topic is EUR 16.5 million.</p> <p>Applicant Private¹⁰² Members of the EU-Rail JU part of consortia responding to this topic should provide in-kind contributions to additional activities to be declared via the template model available on the F&T portal. The amount of total in-kind contributions (i.e. in-kind contributions for operational activities and in-kind contributions for additional activities) should be no less than 1.263¹⁰³ times the funding request, in aggregate, of these applicant Private Members. Any discrepancy shall be well and duly justified.</p> <p>In this respect, the grant agreements will set, in principle, annual deliverable on in-kind contributions for the projects selected under this topic, as well as mandatory reporting requirements, for those applicants who are Private Members of the EU-Rail JU.</p>
Indicative project duration	48 months.
Type of Action	Innovation Action
Technology Readiness Level	Activities are expected to achieve a minimum between TRL 5 and TRL 7, depending on the enabler addressed, or higher by the end of the project – see General Annex B for a guide to the TRL definitions and criteria to be used.
Admissibility conditions	Regarding admissibility conditions and related requirements, part A of the Horizon Europe Work Programme 2021-2022 General Annexes applies with the following exception: the limit for a full Innovation Action application is set to 120 pages.

¹⁰² As defined in Article 2(5) of Council Regulation (EU) 2021/2085.

¹⁰³ In order to support a leverage factor of no less than the ratio between the contribution from members other than the Union and the Union financial contribution, as on the basis of Articles 88 and 89 of Council Regulation (EU) 2021/2085.

<p>Special skills and/or capabilities expected from the Applicant(s)</p>	<p>Applicants shall ensure that their proposals and consortium reflect the aggregated expertise to perform the activities and achieve the objectives set by the Destination:</p> <ul style="list-style-type: none"> • Expertise from rail infrastructure managers and railway undertakings, which should allow <ul style="list-style-type: none"> – defining main challenges, use cases and functional needs, – specifying, prioritizing and clustering demonstrators to ensure that researched innovative processes, operational and technological solutions are covered, – hosting the demonstrations and providing test trains/facilities, – providing data structures and content as well as processes, e.g. certification which can be subject for digitalisation. • Expertise from rail suppliers (system integrators, manufacturers and/or technology providers), which should allow, jointly, <ul style="list-style-type: none"> – proposing operational and technological innovative solutions to identified use cases and functional needs, – identifying the technical requirements and interface specifications, aligned with the System Pillar architecture, – designing, developing, prototyping and delivering innovative operational & technological solutions and systems to be integrated within the demonstrations, depending on the specific target TRL level. • Expertise from research institutes and academia, which should allow <ul style="list-style-type: none"> – planning, developing, studying, testing and evaluating solutions, systems and demonstrators together with the previous categories of expertise, – supporting any possible scientific or methodological issues that may arise during the performance of the action – contributing to other aspects of the innovation cycle, as well as to the procedural aspects for validation, certification, etc. • Complementary expertise from other sectors and parties, with particular attention to SMEs and Start-ups, which may contribute to enhance the actions' outcome.
<p>Contribution to the monitoring and implementation, standardisation of the EU-Rail Programme</p>	<p>The action resulting from this topic is identified as a “flagship project” expected to perform, by the completion of the research and innovation lifecycle, “large scale demonstrations”, in the meaning of Council Regulation (EU) 2021/2085. Hence, the action is a key contributor to the achievement of the objectives identified in the Master Plan¹⁰⁴ as further detailed in the Multi-Annual Work Programme¹⁰⁵.</p> <p>In this respect, applicants are expected to deliver relevant information (data, results, etc.) as mutually agreed, to the JU and the Linked Project[s] to contribute to the advancement of the Innovation and System Pillars¹⁰⁶ activities, as well as in view of the development and implementation of EU policy and legislation (including Technical Specifications for Interoperability and Common Safety Methods) and the development of European standards. As specified in section</p>

¹⁰⁴ Master Plan available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

¹⁰⁵ MAWP available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

¹⁰⁶ Refer to the Multi-Annual Work Programme available at <https://shift2rail.org/about-europes-rail/europes-rail-reference-documents/europes-rail-key-documents/>

	<p>2.3.3.2 of the AWP 2022, and to facilitate contributions to European or international standards, the EU-Rail grant agreements will include an additional information obligation related to standards. Beneficiaries must inform the EU-Rail JU (up to four years after the end of the action) if the results can be reasonably expected to contribute to European or international standards.</p> <p>As part of its internal control and management framework, the JU will perform a of reviews and maturity checkpoints to assess the overall progress against the project plan and against the performance and TRL targets. Depending on the outcome of these reviews and maturity checkpoints(s), the scope of the project may be revised and/or funding reduced in accordance with the provisions of the relevant grant agreement. Mitigation actions may be requested by the JU as condition for continued funding.</p> <p>The proposal shall consider the necessary resources – FTE and/or other – to ensure the monitoring of the “Flagship Project” via regular reporting, reporting of data for the Programme KPIs, etc.. A EU-Rail Governance and Process Handbook is available here : https://shift2rail.org/participate/</p>
Linked Projects	<p>As specified in section 2.3.3.2 of the AWP 2022, in order to facilitate the contribution to the achievement of the EU-Rail JU objectives, the options regarding 'linked actions' of the EU-Rail Model Grant Agreement and the provisions therein, is enabled in the corresponding EU-Rail JU Grant Agreements.</p> <p>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:</p> <ul style="list-style-type: none"> • HORIZON-ER-JU -2022-FA1-01: Network management planning and control & Mobility Management in a multimodal environment and Digital Enablers • HORIZON-ER-JU -2022-FA2-01: Digital & Automatic up to Automated Train Operations • HORIZON-ER-JU -2022-FA3-01: Intelligent & Integrated asset management • HORIZON-ER-JU -2022-FA4-01: A sustainable and green rail system • HORIZON-ER-JU -2022-FA5-01: Sustainable Competitive Digital Green Rail Freight Services <p>Please note that the list non-exhaustive as additional Linked Projects may follow at a later stage of the programme implementation to complement the activity.</p>
Funding of only one project per topic	EU-Rail JU may award up to one project with funding depending on the outcome of the evaluation and the complementarity of the proposed actions.
Retroactive starting date of the grant	The starting date of grants awarded under this topic may be as of the submission date of the application. Applicants must justify the need for a retroactive starting date in their application. Costs incurred from the starting date of the action may be considered eligible.
Lump Sum grant	Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-

	2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025). [[This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under ‘Simplified costs decisions’ or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/ls-decision_he_en.pdf]].
Lower funding rate	The funding rate of the action is 60% of the eligible costs to achieve the leverage effect established in the SBA. Each Consortia may decide internally different funding rates in line with the provisions of Article 34 of Horizon Europe nevertheless complying with the overall funding rate of 60%.
Award criteria additional details	The award criteria included in the General Annexes of the Horizon Europe – Work Programme 2021 – 2022 are complemented with additional criteria as specified in Annexe 8 this Work Programme.
Additional dissemination obligations	In addition, as specified in section 2.3.3.2 of the AWP 2022, and to facilitate contributions to considering the key contributing role of this topic, in designing the dissemination and communication activities, the proposal shall consider that the “Flagship Project” will be part of the overall EU-Rail Programme and the planning of key events – demonstrations, participations to fair, etc. – will be coordinated at Programme level and by the “Stakeholder Relations and Dissemination” structure of the JU.

Expected Outcome:

Building upon the results of S2R as well as EU-member states rail research and innovation activities, the Flagship Project stemming from this topic is expected to contribute specifically in regional solution linked to system architecture approaches, CCS & Operations, rail infrastructure assets, Rolling Stock as well as customer Services.

Solutions should demonstrate that costs for these areas can be lowered and that solutions can be subsequently deployed under operational conditions. Thus, the main focus of this project is to develop in all areas solutions which can be demonstrated under lab-conditions and deployed in an operational environment in a subsequent, fully integrated demonstrator project.

The Flagship Project stemming from this topic is expected to contribute to Europe’s Rail Programme with the following outcomes:

- possible operational adaptation of the proposed solution to meet the specific requirements of low density lines,
- demonstration of the possibility of scaling up as a European solution,
- develop solutions up to proof of concept
- demonstrate solutions in laboratory conditions up to in real operational conditions,

- demonstration of the feasibility of proposed technical solutions and preparatory work for fully integrated demonstrator under operational conditions set for the future.

System, CCS & Operations

In order to reach a cost efficient and customer centric regional system solution, the actions stemming from this destination should define the necessary system requirements (technical and operational) which will be integrated and used by the other FAs in their relevant developments on TMS, CCS and vehicles as well as a data sharing and analysis platform. Hence, a strong involvement of actions from the relevant destinations is required and needs to be secured.

The action stemming from this destination should will also provide relevant input in the area of regional lines to the System Pillar activities.

Assets

Building upon the work developed within S2R and other research and innovation activities, this destination will focus on developing cost-efficient components including wireless and energy self-sufficient infrastructure components to decrease the operational and overhead cost.

Assessment of using multimodal (rail/road) fuelling stations for regional services taken into consideration input from other Destination should be also covered.

Rolling Stock

Building upon the work developed in S2R and other research and innovation activities, this destination should develop design concepts of a light vehicle base and various modular concepts to be adapted for flexible rail passenger (up to 100 passengers) services with particular focus on the development of a light vehicle due to wireless solutions, on-board information systems and modular vehicle architecture (e.g. for interiors, allowing easy customisation of lay-out, suitable for various operators and line characteristics). The solutions should also be environmentally friendly as well as ensuring interoperability and/or high level of standardisation for regional lines also with no or limited connection to mainline traffic.

Customer Service

In addition, building upon the work developed within S2R and other research and innovation activities, the action stemming from this destination should should contribute to develop and/or demonstrate highly accurate multimodal passenger service information on-board and/or at railway stations (including people and goods management) to allow for a smooth journey from railway to other modes and vice versa to bridge the challenging last-mile issue in regional areas. Intelligently match demand in regional areas to create flexible time-schedules solutions, e.g. in case of events.

Integrated demonstrator preparatory work

An important outcome of this destination is the preparatory work for integrated demonstrators up to TRL8 within the duration of the programme to showcase a high number of solutions developed and adapted for regional services can be deployed under operational conditions. In particular taking into account the European dimensions.

The Flagship Project stemming from this topic shall deliver, by 2025 demonstrations under the following scenarios:

Regional Railway System (CCS & Operations) Demonstration

Demonstrators linked to technical enablers developed within **Destination 6**:

- Demonstrate a single integrated Operations Control Center (OCC) covering interlocking, radio blocking and traffic management for regional lines that are not functionally/operationally connected with mainline (TRL 4/5).
- Demonstrate simple on-track radio network based on the findings in destination 2 related with cost effective communications, supporting all FRMCS applications, minimizing civil works and energy consumption, to the achievement of cost effective Gigabit Train, the use of public network coverage and compatibility with main lines (TRL4/5)

Demonstrator linked to technical enablers developed within **Destination 1**:

- Demonstrate a specific application for Traffic Management Systems for regional lines improving resilience of a connected rail network, optimizing train operations including disturbing events taking into account high/low-demand situations (disturbance and distraction) (TRL 5).

Demonstrators linked to technical enablers developed within **Destination 2**:

- Demonstrate a specific application for safe environment perception solutions, including signal reading and obstacle detection, supporting cooperative awareness, supported by virtual certification (TRL5)
- Demonstrate the suitable application of FRMCS specifications, V2X, 5G considering the economic viability for regional lines (TRL5)
- Demonstrate a specific application for absolute train positioning highly accurate and safe, incorporating new sensors for regional use (TRL5)
- Demonstrate a specific application for train integrity for regional trains (TRL 5)
- Demonstrate a specific application for Train length detection for regional trains (TRL4)
- Demonstrate the suitability of a digital platform for CCS validation & TSI certification and authorization for Regional Lines (TRL5).

This requires a strong involvement of and interaction between actions from relevant other destinations but also provides relevant input in the area of Regional Lines (e.g. characterization of existing regional lines across Europe and future expectations and high level requirements) to the System Pillar activities.

Assets Demonstration

- Demonstrate a systemic approach with the implementation of different railway assets in particular for cost-efficient wireless, energy self-sufficient wayside components in particular CCS track-side components (e.g. switches, level crossings) and if applicable for track vacancy detections and signalling shall be evaluated and demonstrated (TRL4/5).

Suitable customer services

- Demonstrate cost-efficient integration of on-board information of multimodal services integrating regional multimodal services such as carsharing (TRL4/5)
- Demonstrate passenger congestion rate monitoring, flow optimization application as well as a low-cost passenger information system for regional services developed within this action (TRL4/5)

The action to be funded under this Destination shall also provide technical and operational requirements (and all necessary elements) for the for the developments of “Destination 1” enablers 1, 3, 4, 5, 13, 14, 15, 17, 18, 19, 23 and 27 to be developed under the action to be funded under **Destination 1 - Network management planning and control & Mobility Management in a multimodal environment and Digital Enablers.**

The action to be funded under this Destination shall also provide technical and operational requirements (and all necessary elements) for the for the developments of “Destination 2” enablers 2, 3, 4, 5, 6, 7, 9, 10 and 14 to be developed under the action to be funded under **Destination 2 – Digital & Automated up to Autonomous Train Operations.**

The action to be funded under this Destination shall also provide technical and operational requirements (and all necessary elements) for the for the developments of “Destination 4” enablers 2 and 3 to be developed under the action to be funded under **Destination 4 – A sustainable and green rail system :**

Scope:

The Flagship Project stemming from this topic shall develop under the following capabilities the enablers and any other which may contribute to deliver the aforementioned expected outcome:

CCS & Operations

1. Develop a destination 6 specific application based on respectively improving generic application developed in destinations 1 and 2 of several technical enablers and components for a cost-efficient performant control command and signalling system adapted to Regional Lines. Individual (non- integrated) technical enabler demonstrations in this first Call (TRL4/5).
2. Develop a single integrated Operations Control Centre (OCC) covering interlocking, radio blocking and traffic management for regional lines that are not functionally/operationally connected with mainline. This integrated OCC will reduce the software and hardware compare to traditional non integrated architecture while ensuring the same safety level (TRL4/5 in 2025).

The Flagship Project stemming from this topic shall develop the functional and operational requirements related to the area of CCS and operations as specified in the Expected outcome above.

Asset

3. Develop based on the work of S2R¹⁰⁷, infrastructure components and wayside elements focused on Regional Railway cost drivers (e.g. level crossings, switches) which are energy self-sufficient and/or wireless enabled (by using the simplified communication system developed in CCS and Operations; enable remote control or full or partial automation and/or autonomous operation (TRL4/5 in 2025). In addition, develop novel concepts to

¹⁰⁷ ETALON (D4.1 and D6.1): https://projects.shift2rail.org/s2r_ip2_n.aspx?p=S2R_ETALON
X2Rail-4 (D11.1): https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-4
In2Track (D2.3): https://projects.shift2rail.org/s2r_ip3_n.aspx?p=IN2TRACK
Smart2 (D1.2): https://projects.shift2rail.org/s2r_ip5_n.aspx?p=S2R_SMART2

decrease costs of the whole life cycle cost of those wayside elements, covering all phases from design to maintenance considering the regional specificities (TRL3 in 2025).

The Flagship Project stemming from this topic shall develop the functional and operational requirements related to the area of Assets as specified in the Expected outcome above.

Rolling Stock

4. Concept of modular light-weight vehicle and/or with alternative propulsion system (TE: light, flexible and modular vehicle) TRL3 by 2025 applicable for both regional lines with or without no/limited connection to mainline traffic. This could include the following areas:
 - Verification of applicability of the regulatory framework and proposed adjustment if applicable (e.g. LOC-PAS, ENE TSIs, certification and authorisation processes for vehicles operating on regional lines with no or limited connection to mainline traffic)
 - Application of components allowing a force-flow optimised modular lightweight design, assuming an adjustment of the provisions in the respective TSIs
 - Design oriented to reduce cabling, distributed both inside the Car and along the whole Train (building upon the result of S2R TD1.2¹⁰⁸)
 - Multimodal interior for fast changing interior (e.g. bike-racks, increased seating, freight).
 - Apply and adapt Virtualisation of Rolling Stock based on S2R results concerning High SIL Brake Control and Adaptive Adhesion control systems¹⁰⁹ develop a vehicle design to replace HW components (pneumatics, electro-pneumatics and mechanics) with embedded software and electronics, with a consequent reduction of cost, cabling/piping, weight and maintenance effort (TRL5 by 2025).
5. Develop a concept for alternative fuelling/charging stations for regional railway being interoperable with other road/rail vehicles (TRL3 by 2025).

The Flagship Project stemming from this topic shall develop the operational and functional requirements related to the area of Rolling Stock as specified in the Expected outcome above.

Customer service

6. Develop cost-efficient integration of on-board information of multimodal services integrating regional multimodal services such as carsharing (TRL5 by 2025). Developments need to take into account solutions stemming and related to work on the ontology networks that have been produced in previous Shift2Rail¹¹⁰ to align with CEN standards such as Transmodel as well as with the connections to National Access Point (TRL7 by 2025).
7. Based on the work developed in S2R¹¹¹, develop passenger congestion rate monitoring, flow optimization application as well as a low-cost passenger information system (by e.g. also using train positioning, FRMCS) for regional services while integrating multimodal

¹⁰⁸ CONNECTA-2 (D1.1): https://projects.shift2rail.org/s2r_ip1_n.aspx?p=CONNECTA-2

¹⁰⁹ CONNECTA (D5.1 and D5.2) https://projects.shift2rail.org/s2r_ip1_n.aspx?p=CONNECTA

¹¹⁰ Connective (D1.5): https://projects.shift2rail.org/s2r_ip4_n.aspx?p=CONNECTIVE

¹¹¹ In2Stempo (D6.1): https://projects.shift2rail.org/s2r_ip3_n.aspx?p=IN2stempo and Fairstation D4.2 https://projects.shift2rail.org/s2r_ip3_n.aspx?p=FAIRSTATIONS

services at railway stations. Such an application will be using the developments done in Destination 1 in the context of multimodal timetable integration. (TRL6 by 2025)

The Flagship Project stemming from this topic shall develop the functional and operational requirements related to the area of Customer service as specified in the Expected outcome above.

Developments on all those enablers should also cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions.

Integrated demonstrator preparatory work

Deliver a list of requirements and an implementation plan of activities for delivering at least one integrated demonstrator per line type (interoperable, functionally separated), which will showcase the demonstration of solutions in real operational environment on at least two Regional Lines.

The action shall actively contribute to measure and monitor the specific quantitative KPIs defined in the Destination description above, including its contribution to the Europe's Rail Master Plan impacts.

The action shall actively contribute to the EU-Rail standardisation rolling development plans wherever relevant. Similarly, the action shall contribute to the development and implementation of EU policy and legislation including Technical Specifications for Interoperability and Common Safety Methods, as well as to publications of the System Pillar.

Collaboration work required with other FAs

The action to be funded under Destination 6 should foresee developing a deliverable capturing specific requirements described in the Expected scope and relevant for the action to be funded under Destination 1, Destination 2, and Destination 4, suggested to be delivered indicatively by M6.

The action to be funded under Destination 6 shall foresee a common activity/task related to the review of system specifications to be developed by the action to be funded under Destination 1, Destination 2, Destination 4.

The action to be funded under Destination 6 shall foresee a common activity/task related to the Preparatory works on the integration and pilot test(s) of the technical enablers to be provided by the action to be funded under Destination 1, Destination 2, Destination 4 for the demonstration to be carried out in the action to be funded by Destination 1, Destination 2, Destination 4.

Interaction with the System Pillar

The System Pillar aims to guide, support and secure the work of the Innovation Pillar (i.e. to ensure that research is targeted on commonly agreed and shared customer requirements and operational needs, compatible and aligned to the system architecture), and the Innovation Pillar will impact the scope of the System Pillar where new technologies or processes mean that innovations can drive a change in approach, as well as delivering detailed specifications and requirements.

In this respect, the proposal should allocate necessary resources that would be dedicated to areas linked to the System Pillar conceptual and architecture works – particularly addressing specification development (the interaction is illustrated in the System Pillar – Innovation Pillar interaction note (Annex VI of this Work Programme)). The alignment of the activities will primarily take place during the Grant Preparation Phase and ramp up phase of the awarded proposal, and there will be continued, structured and regular interaction through the life of the project

Gender dimension

In this topic the integration of the gender dimension (sex and gender analysis) in research and innovation content is not a mandatory requirement.

Annex VIII – 2022 Call for proposals – Evaluation Criteria

Part D of the Horizon Europe Work Programme 2021-2022 General Annexes applies regarding the award criteria, scores and weighting upon which the proposals will be evaluated, with the following addition:

- Under the criteria “Excellence”, “quality of the proposed joint activities to achieve the deliverables”
- Under the criteria “Impact”, “quality and credibility of the action to contribute achieving the EU-Rail Master Plan objectives and the expected impact of the EU-Rail Multi-Annual Work Programme”.
- Under “quality and efficiency of the implementation”, “Appropriateness of the project management structure and quality of the proposed coordination”.
-

	Excellence¹¹²	Impact	Quality and efficiency of the implementation
Research and innovation actions (RIA) Innovation actions (IA)	<ul style="list-style-type: none"> • Clarity and pertinence of the project’s objectives, and the extent to which the proposed work is ambitious and goes beyond the state of the art. • Soundness of the proposed [for the first stage: overall] methodology, including the underlying concepts, models, assumptions, interdisciplinary approaches, appropriate consideration of the gender dimension in research and innovation content, and the quality of open science practices, including sharing and management of research outputs and engagement of citizens, civil society and end-users where appropriate. • Quality of the proposed joint activities to achieve the deliverables. 	<ul style="list-style-type: none"> • Credibility of the pathways to achieve the expected outcomes and impacts specified in the work programme, and the likely scale and significance of the contributions from the project. • Suitability and quality of the measures to maximise expected outcomes and impacts, as set out in the dissemination and exploitation plan, including communication activities. • Quality and credibility of the action to contribute achieving the EU-Rail Master Plan objectives and the expected impact of the EU-Rail Multi-Annual Work Programme 	<ul style="list-style-type: none"> • Quality and effectiveness of the work plan, assessment of risks, and appropriateness of the effort assigned to work packages, and the resources overall. • Capacity and role of each participant, and the extent to which the consortium as a whole brings together the necessary expertise. • Appropriateness of the project management structure and quality of the proposed coordination.

¹¹² The following aspects will be taken into account, to the extent that the proposed work corresponds to the description in the work programme.