ANNUAL ACTIVITY REPORT

2023

EXECUTIVE VIEW

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The Europe's Rail Joint Undertaking (EU-Rail) became the legal and universal successor of the Shift2Rail Joint Undertaking (S2R JU or S2R). Hence, EU-Rail has succeeded in the management of the S2R JU Research and Innovation Programme.

However, in this report, references may still be made to S2R Programme, S2R Other Members, S2R R&I, S2R Regulation, S2R JU, S2R etc. to identify all the activities and governance inherited by EU-Rail and related to the former S2R JU.

Contents

Foreword

It is a great fortune of our time that the pressure to reduce greenhouse gas emissions is coinciding with a rapid revolution in digital technologies. As the world looks to increase sustainability, we have more and more tools to innovate. We just need to make sure that we reap the full benefits of these opportunities – for the environment, for maximum connectivity, and for industrial competitiveness.

Rail is a key ally in the race to reduce transport emissions, being one of the most sustainable transport modes available. The challenge is to build on the rich history of rail to bring it fully into the digital era. This will make rail more attractive for passengers and freight alike.

Building on the successes of its predecessor Shift2Rail (S2R), the Europe's Rail Joint Undertaking (EU-Rail) has taken major steps towards the digitalisation of rail freight, opening the door to new operations and services. We are getting closer to the deployment of a European Digital Automatic Coupler solution.

2023 was an intense year for Europe's Rail: new synergies, new beneficiaries, and the much-anticipated operationalisation of the Joint undertaking (JU) Deployment Group. I look forward to seeing the results of the first joint project between SESAR 3 JU and Europe's Rail, on traffic management. I am equally enthusiastic about the collaboration between Europe's Rail and the Smart Networks and Services Joint Undertaking (SNS JU), on the testing and operational validation of the next European Union (EU) rail communication system. This will be a key enabler of further innovation, ensuring attractive, innovative, and tailor-made rail services.

The work done by Europe's Rail will bring us closer to delivering the next generation Automated Train Control system, optimising operations and increasing capacity on the network. This will certainly attract more freight to rail.

Success is a continuous journey. Thanks to the commitment of its members and stakeholders, Europe's Rail has already made huge progress. I look forward to more successes as we reinforce the role of rail in Europe's transport and mobility system and step up the competitiveness of the EU rail supply industry.

Magda Kopczyńska,

Director-General for Mobility and Transport, European Commission

Europe's Rail in 2023

2023 has been the year where EU-Rail has successfully run two Research and Innovation (R&I) programmes and largely closed the S2R R&I operational activities according to plan.

2023 was an intense year for the operational activities of the JU as all the technical demonstrators (TDs) of the S2R programme have been delivered and have demonstrated their final results. At the same time the six Flagship Projects (FPs) responsible for undertaking the initial implementation of the Flagship Areas (FAs) launched their activities. All FPs have also established collaboration and working methods amongst themselves as well as with the EU-Rail System Pillar, which provided the first outputs this year.

During 2023, EU-Rail launched two calls for proposals and diverse tenders to implement the R&I programmes, amongst them the second year for the System Pillar activities, the call for expression of interest for the new Scientific Steering Group (SSG), and the setup of the EU-Rail Deployment Group. In 2023, EU-Rail also kick-started the first set of exploratory research activities with eight new grant agreements and the new SSG.

2023 was also marked for the first ever definition of synergy topics call across the JU's establishing close cooperation between EU-Rail and SESAR 3 JU under the EU-Rail call 2023-1 launched in October 2023. Additionally, another call was launched with the SNS JU under the EU-Rail call 2024-1 in January 2024. As a result, EUR 2.5 million coming from SESAR 3 JU and EUR 1 million from SNS JU enlarged the EU-Rail programme field of action, respectively for traffic management and the next EU-rail communication system, where rail works together with other modes of transport to ensure attractive, innovative, and tailor-made rail services.

The next EU-Rail communication system is a key enabler for further innovation that has been added to the EU-Rail programme, building on activities previously performed within different organisations outside EU governance. The sector and the European Commission (hereinafter "the Commission") have entrusted EU-Rail to encourage and ensure the rail system's ability to embrace this new solution with R&I as from 2024. EU-Rail has striven to reach this goal through the activities of its Innovation Pillar, preparation for Technical Support Instrument (TSI) updates, its System Pillar, and with migration planning and the deployment recommendations of its Deployment Group. This work is based on cooperation with the EU institutions and bodies for policy setting, including the EU Agency for Railways (ERA), the rail sector; in particular, the organisations which have heavily invested in the Future Railway Mobile Communication System (FRMCS),[1] the telecommunication sector, the JU private Members contributing with additional in-kind activities, and with many other researchers contributing to the EU-Rail programme under Horizon Europe.

Following the successful Space for Innovation in Rail event in 2023 under the Spanish Presidency of the Council of the European Union (hereinafter "the Council"),[2] EU-Rail has set up the elements for a concrete project on the European Geostationary Navigation Overlay Service (EGNOS) for rail in cooperation with the EU Agency for the Space Programme (EUSPA),[3] and with the European Space Agency (ESA),[4] under the strategic leadership of the Commission and in full coordination with ERA.[5] Through R&I, EU-Rail aims to provide support regarding the technical and operational elements to reach competitive and resilient satellite-based rail services.

Additionally, in the 2023 Greening Freight Transport communication of the Commission to the European Parliament (hereinafter "the Parliament"), the Council, the European Economic and Social Committee, and the Committee of the Regions, the deployment of digital automatic couplings (DAC) technology, supported by the R&I of EU-Rail, is highlighted as a game-changer for European rail freight.[6] The Commission is looking forward to developing a comprehensive migration strategy to coordinate deployment, with the help of EU-Rail.

In the same package, the Commission also published a proposal for a regulation on the use of railway infrastructure capacity in the Single European Railway Area (SERA).[7] In the regulation, the rail infrastructure managers are called on to ensure alignment, in particular regarding the digitalisation of capacity and traffic management, through the work of EU-Rail. Additionally, they shall contribute to EU-Rail's work in this regard.

EU-Rail's R&I activities are designed to deliver concrete solutions addressing the climate change crisis the world is facing, climate mitigation, and adaptation. The JU Programme Office and its members are well aware of this urgency and the importance that the work of our integrated programme has, covering innovative solutions' lifecycle from exploratory research to pre-implementation and deployment.

In 2023, for the preparation of its call 2024-1, EU-Rail has planned new call topics in the FA on Digital & Automated up to Autonomous Train Operations and in the on FA Sustainable Competitive Digital Green Rail Freight Services. This additional effort is expected to lead to a faster increase in competitiveness and attractiveness of the rail sector and its European industries worldwide, which can contribute to delivering the EU policy expectations. Furthermore, EU-Rail continued to support disruptive innovations in the preparation of its call 2024-1, with the launch of a topic covering new approaches for guided transport modes such as hyperloop.

The launch of the R&I activities of the EU-Rail integrated programme, build upon the results and advances of the S2R programmes, shapes the mission-oriented nature of the JU, based on openness and inclusiveness, answering the call of the member states and the Parliament to deliver impact and added value to European citizens. Synergies with other EU, national and regional, programmes and partnerships shall provide opportunities to complement the series of actions expected from the rail sector. In this regard, EU-Rail is interacting with the European Railway Research Advisory Council (ERRAC) on complementary activities.

1   https://uic.org/rail-system/telecoms-signalling/frmcs

2   https://rail-research.europa.eu/calendar/space-for-innovation-in-rail-towards-satellite-based-ertms/
3   https://www.euspa.europa.eu/
4   https://www.esa.int/
5   https://www.era.europa.eu/
6   https://transport.ec.europa.eu/system/files/2023-07/COM_2023_440.pdf
7   https://transport.ec.europa.eu/system/files/2023-07/COM_2023_443_0.pdf

Maintaining stakeholder relations, and communication and dissemination of results ensures the visibility and uptake of the progress achieved. Sound financial and risk management and compliance will underpin the implementation of the programme during its lifecycle. The cohesion that EU-Rail has created within the European rail industry builds upon a small team of passionate professionals dedicated to deliver this new ambitious integrated programme.

In decision 17/2023, the EU-Rail Governing Board (GB) takes note of the collective political commitment expressed by the EU-Rail private Members, their constituent, and affiliated entities to increase the amount of their contribution to EU-Rail by EUR 30 million until 31 December 2031 (i.e. for a total contribution of minimum of EUR 630 million), in case this is necessary to match a possible increase in the EU financial contribution to EU-Rail as a result of the association of the United Kingdom to the Horizon Europe Programme. An expected positive impact was acknowledged in terms of accelerating the delivery on the relevant policy objectives and rapidly progressing in key areas.

EU-Rail also implemented a phasing-out plan, approved by the GB in December 2023, highlighting the steps for the administrative closure of the Programme, without precluding a possible continuation of the EU investment in a possible successive partnership under the next Union's Framework Programme, in accordance with the Single Basic Act (SBA).

The recovery plan for reports and payments put in place in 2023 was implemented thanks to the contribution of a committed team and the actions taken by the EU-Rail Members. This resulted in the execution of 85.2% of EU-Rail payments appropriation (95% reached on the administrative payments) for operational activities by the end of the year. This can be divided into 67% for S2R projects (an increase compared to the 41% in 2022) and 95% for EU-Rail projects. In 2024, the S2R projects will be administratively concluded with the last payments released. A reports and payments plan has been built to this effect.

The Executive Director (ED) would like to express all his gratitude to the EU-Rail Founding Members, the S2R Members, the EU-Rail staff, the Member States Representatives, and the observers for the collaboration and support during 2023, making those significant results possible.

Giorgio TRAVAINI,
Executive Director
Europe's Rail Joint Undertaking

Call 2023 in Figures

1 Call launched in **2023**

99 beneficiaries in funded projects

€21.2 million of total project value

€14.1 million EU-Rail funding awarded

47 SME participations were part of the evaluated proposals in the 2023 call

24 SME participations were included in the proposals retained for funding

Executive Summary

2023 marked the year of operational closure of the S2R programme and its projects. All the TDs of the S2R programme have delivered and demonstrated their final results. At the same time, in 2023, the EU-Rail programme started effectively with the six FPs responsible for undertaking the initial implementation of the FAs. At the end of the year 2023, they all reached key use cases and requirements for the main technical enablers, which were in most cases already defined. All FPs have also established collaboration and working methods amongst themselves, but also with the EU-Rail System Pillar.

The System Pillar, established in 2023, provided its first outputs, including:

- Interfaces for trackside assets, EULYNX Baseline 4 release 2,

- System Engineering Management Plan (SEMP), Version 2,

- Issuance of draft Version 1 of the Standardisation and TSI Input Plan,

- Issuance of the report on the Version 2 and Version 3 specifications for the FRMCS,

- Issuance of the first version of the Control Command and Signalling (CCS) / Traffic Management System (TMS) data mode.

During 2023, EU-Rail set up the launch for two calls for proposals and diverse tenders to implement the R&I programmes, amongst them the second year for the System Pillar activities, the call for expression of interest for the new SSG, and the setup of the EU-Rail Deployment Group. EU-Rail kick-started in 2023 the first set of exploratory research activities with eight new grant agreements and the new SSG.

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.

EU-Rail aims to accelerate research and development in innovative technologies and operational solutions. This will support the fulfilment of EU policies and objectives relevant for the railway sector, the competitiveness of the rail sector, and the European rail supply industry. In this way, EU-Rail will accelerate the penetration of integrated, interoperable, and standardised technological innovations necessary to support the SERA.

2022 and 2023 activities were influenced by a new crisis resulting from the illegal aggression of Ukraine by Russia. Although EU-Rail R&I has not been directly impacted by the situation, it is not possible to anticipate at this stage the consequences of such dramatic events.

Beyond the operational activities, 2023 was the second year of implementation of SBA Article 13, where EU-Rail took over the responsibility for the coordination of the Back Office Arrangement (BOA) Accounting Services. Three Other BOAs led by other JUs were established where EU-Rail also took a supporting role.

The year 2023 brought 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, partnerships, and bodies with the objective to establish synergies that will result in coordinated and consistent activities, joint R&I projects or administrative synergies, such as, for example, under the BOAs with other JUs,

- Different associations representing the key stakeholders of the rail sector and beyond,

- Third country programmes, in line with the policy priorities of the Commission and the key objective of increasing the competitiveness of the European rail industry.

Finally, in 2023, we continued to focus on 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 continued to reinforce the objectives of initiatives such as the European Green Deal, the Sustainable and Smart Mobility Strategy, and the Digital Decade by disseminating R&I results and showing the future evolution of rail in terms of services for passengers and freight clients. In this respect, in line with its communications strategy, EU-Rail aims to:

- Showcase the innovative technological and operational solutions that result from the R&I activities, in particular those that are demonstrating concrete impact and are ready to enter industrialisation and deployment,

- Raise awareness on the R&I activities by reaching out to stakeholders at the European level, as well as engaging at global events and conferences to promote EU-Rail results,

- Enhance the partnership nature of the JU through communication and dissemination activities that will create opportunities for inclusiveness.

In terms of organisational changes, at the meeting of the GB of 30 November 2022, the ED informed the Board of his intention to step down from his position before the end of his second mandate. He notified the GB that his decision would formalise in 2023, once the necessary administrative steps would be completed. This was formalised on 9 January 2023, when the ED notified his end of service as from 28 February 2023. On 30 January 2023 the GB appointed Mr Giorgio Travaini, Head of the Programme Unit, as ED ad interim as from 1 March 2023.

S2R Programme Status

2023 was a closing year for operational R&I activities under the innovation programmes of S2R. All the TDs have been finalised, showcasing their results after a total of seven to eight years of programme implementation since its launch in advance of the S2R programme implementation end date of 31 December 2024.

The Covid-19 pandemic, as reported in the previous years, has generated a number of additional extension amendments, as well as impacted EU-Rail's ability to administratively close those projects. As a result, this impacted some of the planned last payments of 2023, which have been postponed to 2024. All S2R projects will be administratively closed in 2024.

In this context, the work of S2R members other than the EU (hereinafter Other Members), other beneficiaries, and the JU staff is commendable as they have collectively and individually ensured the conclusion of the R&I activities.

By the end of 2023, the S2R programme reached its operational closing milestones in term of programme implementation. On average, about 99% of the full S2R programme has been realised from an operational perspective, and 101% in term of financial programme execution in total project costs (98% of co-funding executed with payments), in view of reaching the TRL6/7 operational demonstrations planned for conclusion during 2023. In total, it is estimated that the total value of the activities performed in 2023 amounts to EUR 62.9 million, of which EUR 54.6 million was delivered by the Other Members.

During 2023, the JU assessed its R&I activities through a fifth Control Gate Exercise.[8] This exercise took into account the deliverables and reports submitted in the context of the annual review of the active projects coordinated by the S2R Other Member. The JU also ensured through this process that the recommendations made during the previous Control Gate Assessment had been properly applied. The overall result is that the programme benefited from the feedback built upon external expertise.

The programme assessment allowed the JU to confirm that overall, the progress of the activities has been in line with the expectations for a possible operational conclusion of the activities in 2023.

Only four TDs (out of 49) show delays in submitting the last deliverables, not having submitted them by the end of 2023. Such cases have been closely followed up by the JU to ensure that the S2R projects can be closed administratively in principle in the first half of 2024.

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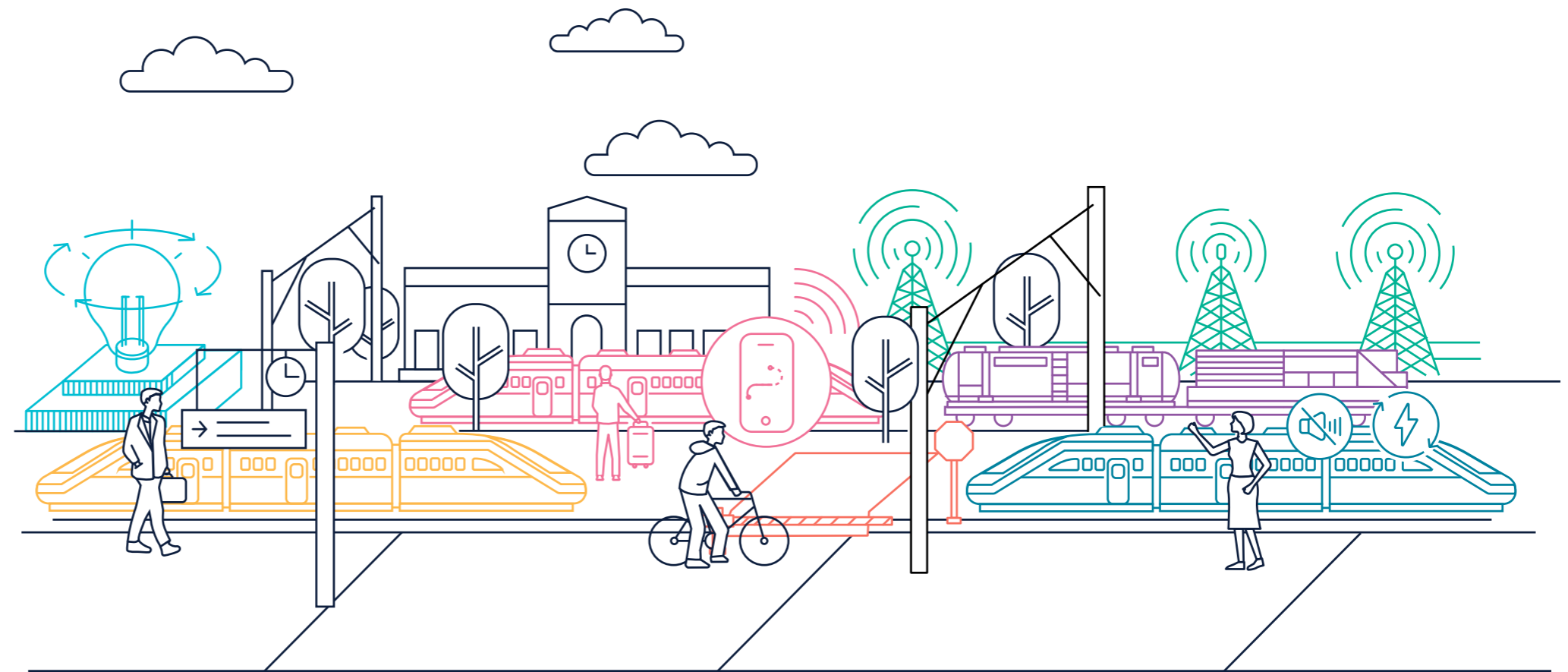
8   In accordance with the procedure set in the S2R Governance and Process handbook, transparently published on the JU's website: https://rail-research.europa.eu/wp-content/uploads/2024/01/ED-DECISION-ED-23-09_Annex_GovProc.Handbook.pdf

Passenger Trains

In 2023, the TDs of Innovation Programme 1 (IP1) advanced significantly towards the completion of the full activities of IP1, estimated in 2023 to 97%. The reason for the non-completion is due to not all deliverables, specifically TD1.3 (car body) and TD1.7 (train modularity), being submitted by the end of 2023. Mitigation actions have been taken to remedy this. Overall IP1 submitted 83% of the deliverables of which eight were planned for 2023. Besides TD1.3 and TD1.7, all TDs have been finalised over the course of 2023 despite delays incurred during the previous year, mainly for TD1.3 and TD1.4 (running gear). This was made possible due to all TDs contributing effectively to the catch-up exercise. However, the progress on TD1.7 was not at the same pace as the rest.

Within TD1.3, each elementary part (composite and metallic) was built for the final assembly of the high speed demonstrator together with all the tooling needed. This was reflected in the submission of the related deliverables.

TD1.4 finished the development of smart running gear components as well as supported the development of a universal cost model (UCM 2.0) in coordination with S2R project NEXTGEAR. In terms of notable technical quantifiable achievements, TD1.4 has met and even surpassed the current EN standards by significantly reducing the weigh of the running gear through the use of optimised alternative materials. Lab-testing and on-track testing were performed to validate the prototypes.

Within TD1.5 (brakes), a newly developed high-safety integrity level (SIL) braking system was installed on a train provided by EUSKOTREN, which served as a field demonstrator. Together with a simplified architecture for the weighed emergency brake, a novel strategy for the distribution of the braking force along the train was implemented to optimise the brake's performance in low adhesion conditions. The system has proven itself in terms of performance and safety level during operational conditions.

TD1.7 still needs to report on the final Key Performance Indicators (KPIs), the details of the final concepts, and the benefits of the new modular concepts for train interiors.

IP1

Traffic Management

100% of progress has been reported on all TDs and thanks to this, Innovation Programme 2 (IP2) has completed its operational activities at the end of 2023.

Within the field of TD2.1 (adaptable communication), tests have taken place on regional lines in Italy, concluding all planned segments of the demonstration of this TD. Bearer flexibility between different technologies such as 3G, 4G, 5G, WiFi, and satellite transparent to the applications was also tested. It was concluded that public networks proved to be a valuable complementation to the private railway radio networks by improving service availability and usable bandwidth. Input has been provided to the International Union of Railways (UIC) project on FRMCS.

It is important to note that, despite last year's slow progress, TD2.4 (smart, fail-safe communications and positioning systems) finalised Virtual Balise (VB) demonstrations based on the Stand-Alone Fail-Safe Train Positioning System.

During the test of VB in Czechia, the position errors mostly amounted to only a few meters. In only one case the error was above ten meters. As a result, incorporating track data into the onboard algorithm emerged as a crucial factor in enhancing safety and accuracy.

During the test in Italy, on-board and trackside operating on a real line, was tested using both a local augmentation network and EGNOS fully integrated in the ETCS (European Train Controlling System). During this test, the position error with local augmentation was below five meters. Additionally, with EGNOS the error was usually around five meters but with a higher variance.

The test of the Stand-Alone Fail-Safe Train Positioning System in Spain integrated the Global Navigation Satellite System (GNSS), inertial measurement unit (IMU), tachometer, and Digital Map to achieve a position confidence interval (3σ) below 20 meters.

In France, the test was based on multi sensor acquisitions, using EGNOS V3 Dual Frequency Multi Constellation (DFMC) emulator. The average distance error was below 0.2 meters and the average speed error was below 0.02 m/s. However, it should be noted that the results did not originate from a real time algorithm execution and did not include a track selectivity functionality.

In Germany, the test was based on the dual channel functionality of GNSS, IMU, speed sensors, and Digital Map. Additionally, the demonstration used the first track position as a given position (no track discrimination). From the demonstration we could conclude that the speed confidence interval did not always cover demanding performance requirements. Furthermore, position errors were sometimes above ten meters, more than 2%, under non-favourable GNSS conditions.

The other TDs progressed to completion in 2023, closing the remaining open points from 2022.

IP2

Optimised Infrastructure

In 2023, Innovation Programme 3 (IP3) closed all its activities with minor deviations to the initial objectives of the Maximum Allowable Operating Pressure (MAWP). As a result, IP3 reached 94% of the estimated work planned in 2023. Only TD3.4 (innovative track materials) and TD3.5 (cost effective tunnel & bridge solutions) did not submit all deliverables by the end of 2023. Mitigation actions have been taken to remedy this. The mentioned deviations resulted in a total IP3 completion of 99%.

It is worth noting that TD3.3 (innovative track design) has established a new parameter for evaluation, called GIP in case the wheel or the rail is in a good condition with regards to passenger comfort (vehicle stability). This parameter has been described as a new geometrical parameter for judging the stability on track in the EN 15302 technical report.[9]

In TD3.8 (intelligent system maintenance), 15 workers utilised a dedicated exoskeleton developed in the programme for approximately 100 hours, engaging in real work activities, such as carrying and positioning concrete conduits weighing between 20 kg and 30 kg. The results indicated a noteworthy 50% reduction in ergonomic risks for the musculoskeletal system, particularly in the lumbar region. Fatigue levels were reduced by up to 30%, and muscle activity saw a decrease of 25%.

Amongst the promising results on unmanned and remotely controlled maintenance inspection, a semi-autonomous motorised trolley was validated during in-field tests in TD3.4 to use contactless Electro Magnetic Acoustic Transducers sensors that can detect rail surface defects, which are difficult to monitor with current technologies, enhancing the defect detection.

The other TDs progressed to completion, closing the remaining open points from 2022.
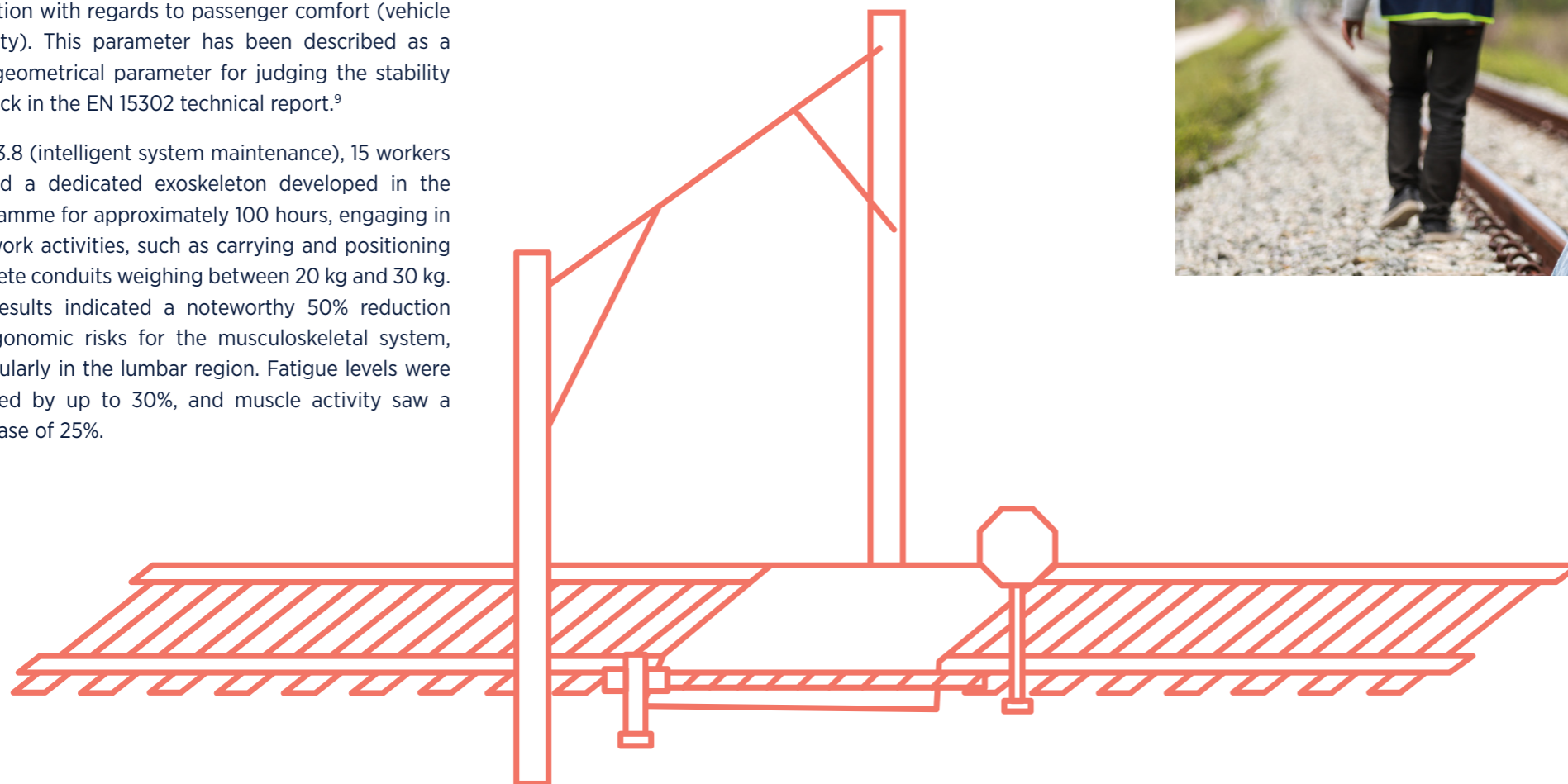
9   CEN/TR17792.:2022.

Digital Services

IP4

Innovation Programme 4 (IP4) has reported a 100% completion rate. As a result, IP4 finished its operational activities at the end of 2023.

In 2023, the Interoperability Framework of TD4.1 allowed up to 31 services for the pilots that were located in Athens, Padua, Warsaw, Liberec, Osijek, and Barcelona to be integrated and demonstrated. This has proven the technical feasibility of the Interoperability Framework to aggregate different transport service providers and services. Improvement to the overall architecture has been developed and tested in the remaining part of the programme. As a result, an overall increase of the performance by 42% from the initial delivered system for the different aspects, such as the shopping orchestrator and issuing orchestrator, was established.

Other R&I work on TD4.3 (booking and ticketing) has led to, amongst other things; the development of an intermodal best price which covers public transit legs, bike sharing, and car sharing. If the costs for single trip tickets of a user exceed a threshold within a day, for example, a MaaS day pass valid for different modes of transport is granted and invoiced. This technically shows the feasibility of applying such schemes for passenger journeys. Similarly, the work under TD4.4 provides the traveller with a new optimal route in case of disruption in real time. This was demonstrated in a pilot in Liberec which included trip tracking for a Travel Service Provider (TSP).

The other TDs progressed to completion closing the remaining open points from 2022.

Rail Freight

IP5

In 2023, the TDs submitted 100% of their planned deliverables. Due to some deviations to the initial objectives of the MAWP, an implementation rate of 99% is estimated concerning the TDs completion.

Innovation Programme 5 (IP5) completed the end-to-end solutions on Condition Based Maintenance, including; new processes, data processing analytics, and dashboard for locomotives and wagons. Additionally, IP5 was a key contributor to the DACcelerate, project of the European DAC Delivery Programme (EDDP). IP5 also delivered good results aimed to improve timetable planning and yard management with a successful demonstration in the Malmö yard. The laboratory and field tests for the bogie with aluminium frame were also successful. Finaly, the first testing campaign for the Extended Market Wagon was largely successful.

The other TDs progressed to completion addressing the remaining open points from 2022.
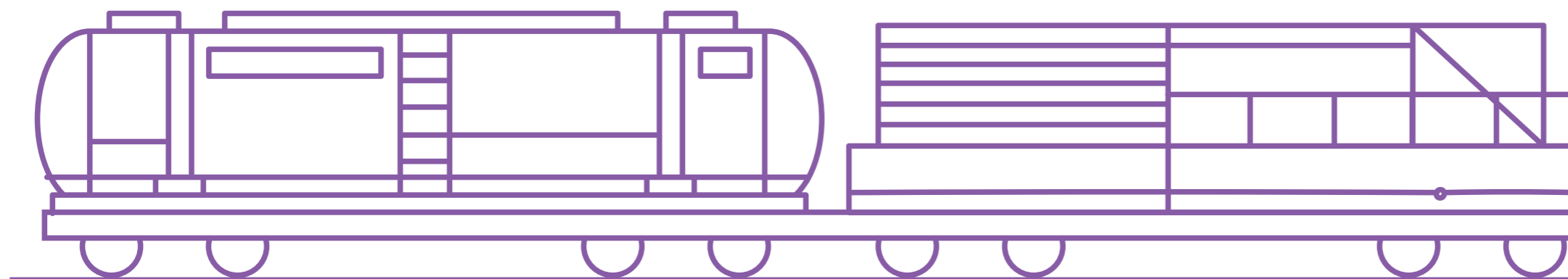
Cross-Cutting Activities

The Cross Cutting Activities (CCA) reached a 100% level of implementation of planned activities for 2023. The focus for 2023 was put on continuing and closing the activity of the Noise and Vibration Work Area as all other areas were completed in 2022.

Regarding exterior noise prediction tools, the focus was put on evaluating the measuring campaigns and analysing the results for the accuracy of exterior noise prediction. Noise separation techniques proved to be of extreme use for pass-by certification tests. Following the campaign on exterior noise prediction, R&I work has been concluded for simulating and predicting the separation of different noise sources. One of the results will be used directly for the improvement of the CEN/TR 16891 standard.

For ground vibration prediction, R&I focused on a holistic approach capable of assessing vibration levels for large-scale studies. Additionally, a hybrid approach was employed combining numerical prediction with experimental results. Validation of a prototype tool in 2023 was successful showing a promising future.

Finally, auralisation and visualition enhanced Virtual Reality scenarios were developed and demonstrated on regional test cases.

CCA

INNOVATION PROGRAMME X
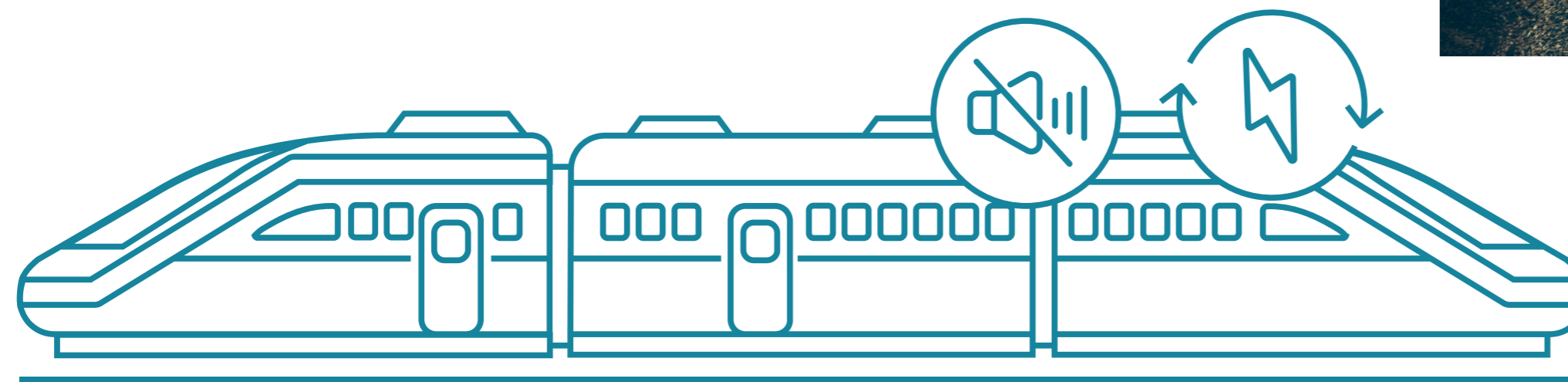
System Architecture and Disruptive Technologies

2023 represented the official handover of the System Architecture activities within Innovation Programme X (IPX) to the EU-Rail System Pillar, following the ramp-up of activities in 2022. The projects delivered the following prefigurating elements for the System Pillar:

- Two consecutive releases of the System Functional Architecture,

- The specification and the set-up of the formal definition of the Conceptual Data Model (CDM),

- The demonstration of the applicability of the CDM for concrete railway scenarios through four relevant cases,

- Regularly uploading and updating the newest versions of the source models of the ontology dictionary, OntoRail.

Due to the low Technological Readiness Level (TRL) and lack of PhDs research involving Artificial Intelligence (AI) adoption in rail, the work focused on developing methodological and experimental proofs-of-concept, benchmarks, models, and simulations.

The proofs-of-concepts were finalised to support the definition of roadmaps, covering the following topics:

- Railway Obstacle Detection and Collision Avoidance,

- Cooperative Driving for Virtual Coupling of Autonomous Trains,

- Predictive Maintenance for Rolling Stock,

- Smart Maintenance at Level Crossings,

- Graph Embedding for Primary Delay Prediction,

- Big Data on Incident Attribution Analysis.

Exploratory activities on environment perception for automation and remote driving and command demonstrated successful final results at the end of 2022 and beginning of 2023. The results of these exploratory activities were prepared for transfer to EU-Rail's Flagship Project 2 (FP2)-R2DATO for further work and step change in TRL.

IPX
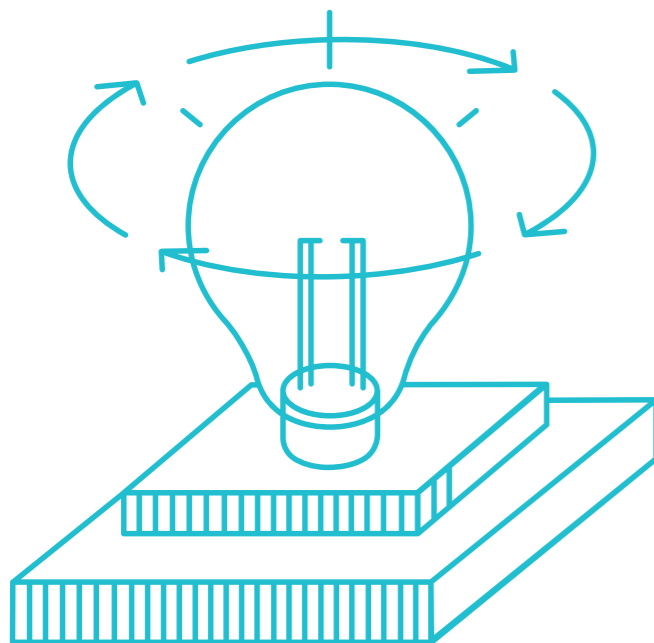
S2R Programme Management

In terms of programme management, 2023 was the fourth year during which reviews of lump sum projects took place. Our experience confirms that, from an operational perspective, the use of lump sums for members' projects does not only result in an administrative simplification, but also effectively bundles efforts in the project review to focus on the achievements of results. The concluded work packages focused on deliverables and milestone approval, which provided the basis for the reimbursement of costs. This has allowed the JU and consortia to focus their efforts in an effective way in order to ensure the delivery of the projects.

In 2023, programme management continued to be influenced by the need to continue monitoring projects affected by the consequences of the restrictions that were put in place during the pandemic. The programme management was also characterised by a monitoring of the closure of activities by the end of 2023, with a focus on the results and achievements of the reporting and payment planning for 2023.

Through the use of a holistic approach, the JU is also able to ensure that interactions between the various IPs are adequately considered and managed, as technological developments in one part of the system could lead to changes in performance, or even create barriers, in other parts. In addition, the CCA includes research on long-term economic and societal trends such as customer needs and human capital and skills, which must be taken into account by the different IPs.

EU-Rail Programme Status

The EU-Rail programme kickstarted in 2022 with an anticipated ramp-up phase of the System Pillar. On the other hand, while the Innovation Pillar underwent the assessment of the first six FPs that started their R&I activities in December 2022, with the notable exception of Flagship Project 5 (FP5), which already started in July 2022 as a result of a fixed early start date before the signature of the grant to ensure the swift ramp-up of DAC prototypes in views of the 2025-2026 demonstration activities.

Additionally, in 2023, EU-Rail kick-started the first set of exploratory research activities with eight new grant agreements, complementing the work of the FPs in often different areas of R&I of the EU-Rail Innovation Pillar.
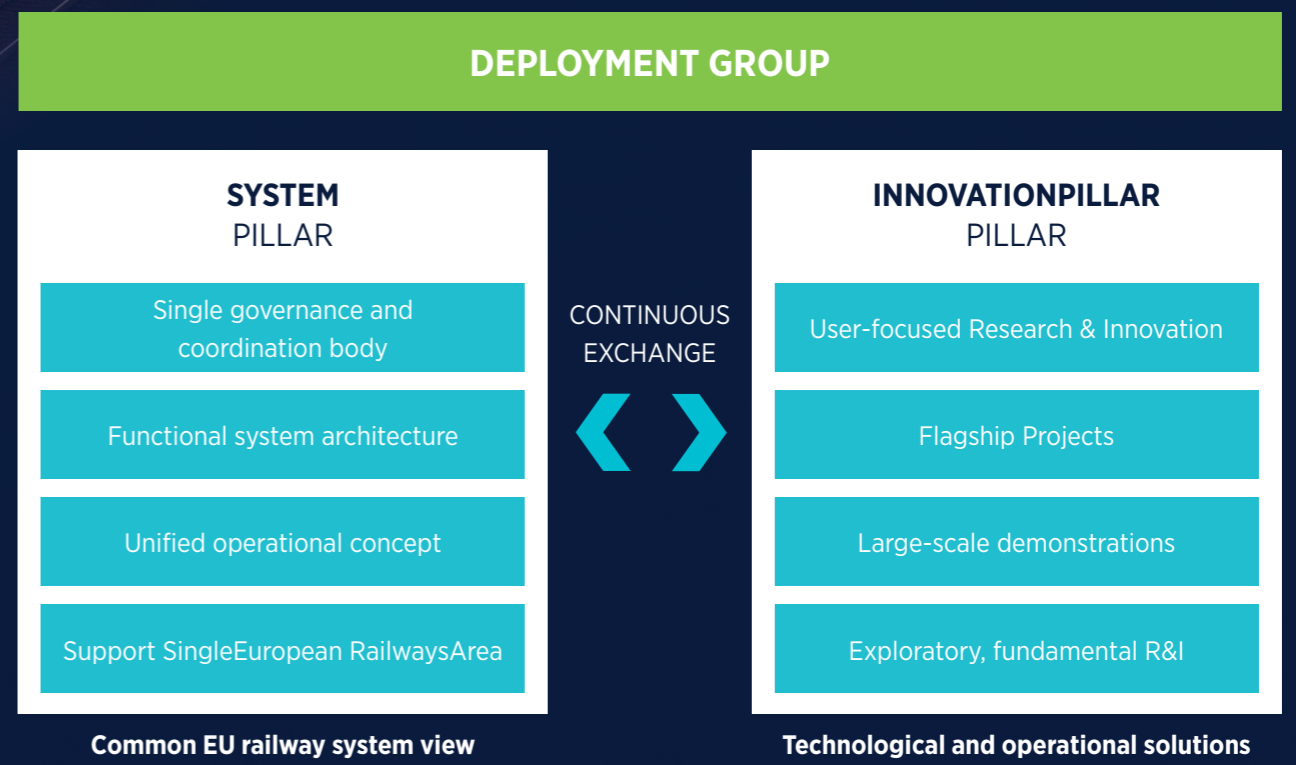
A framework for continuous exchanges between the System Pillar and Innovation Pillar activities as part of the integrated R&I programme has been set up in 2022 and operationalised in 2023, allowing for a bi-directional flow where both pillars provide input and output to each other against a clearly defined series of priorities and objectives.

The Deployment Group, following consultations with the Commission, private Founding Members of EU-Rail, the States' Representative Group (SRG), and the SSG (at that time still acting as the Scientific Committee was launched by a GB written procedure for its establishment in June 2023). At the end of November 2023, the Commission requested support for EU-Rail with regards to the selection process and the proposal of a number of preselected candidate members (i.e., representatives of EU-Rail's Founding Members and representative bodies). After consulting with the System and Innovation Programme Board (SIPB) and considering potential candidates proposed by the SRG, the Deployment Group, the third pillar

of the integrated programme, is expected to be operational in 2024.

In general, the objectives of the integrated programme are as follows:

- Contribute towards the achievement of the SERA,

- Ensure a fast transition to a 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.

DEPLOYMENT GROUP		
SYSTEM PILLAR	CONTINUOUS EXCHANGE	**INNOVATIONPILLAR** PILLAR
Single governance and coordination body		User-focused Research & Innovation
Functional system architecture	❮ ❯	Flagship Projects
Unified operational concept		Large-scale demonstrations
Support SingleEuropean RailwaysArea		Exploratory, fundamental R&I
Common EU railway system view		**Technological and operational solutions**

The System Pillar

The System Pillar is the "generic system integrator" for EU-Rail and the architect of the future of the EU's railway system. Under the SBA, it was established as a fundamental activity of EU-Rail, alongside the Innovation Pillar and Deployment Group.

The System Pillar provides governance, resources, and outputs to support a coherent and coordinated approach to the evolution of the rail system and the development of the system view based on a formal functional system architecture approach to speed innovation and deployment. The System Pillar brings rail sector representatives under a single coordination body.

To achieve this, the System Pillar will deliver a unified operational concept and a functional, safe and secure system architecture with due consideration of cybersecurity aspects focused on the European railway network, to which Directive 2016/797 applies (i.e. the heavy rail network). The system architecture includes; European rail traffic management, command, control and signalling systems, as well as automated train operation. The System Pillar ensures that R&I targets commonly agreed upon and shared customer requirements and operational needs. It further ensures that the system architecture is open to evolution.

In 2023 the System Pillar was fully operational, and all governance and organisation elements were in place.

The System Pillar **Tasks and Domains** are:

- Horizontal domains – Engineering environment Team (EET), Performance-Reliability-Availability-Maintainability and Safety (PRAMS), and Security
- Task 1: Railway System
- Task 2: Control-Command and Signalling (CCS)
- Task 3: Capacity Management System (CMS) and Traffic Management System (TMS)

- Task 4: Digital Automatic Coupling (DAC) and Full Digital Freight Train Operations (FDFTO) System design
- Specific Topic Projects:
  - Harmonised diagnostics.
  - EGNOS (European Geostationary Navigation Overlay Service) for Rail.

The scope and achievements of the System Pillar tasks and domains in 2023 were:

Horizontal domains

The horizontal domains deliver methods, tools and training for the whole System Pillar. The outcomes included:

- Completion of the System Engineering Management Plan Version 1.
- CENELEC changes proposal for harmonisation and modular approaches.
- Processes for Hazard and Risk Analysis and harmonized hazard lists for Operation and System level.
- Cybersecurity
  - Security specification development for TSI input.
  - Cooperation with System Pillar Domains and Innovation Pillar for continuous support of the integration of the security requirements.

Task 1: Railway system

Task 1 consists in defining the business process architecture and Operational Design (Organisational needs, Generic automation needs) for the Railway System, based on and reflecting the Common Business Objectives.

During 2023, the following achievements were accomplished:

- Business Process Architecture and Operational Design, version 1.
- Definition and prioritisation of uses cases of the full railway system.
- Diagnosis of pain points and derivation of target performance Version 1.
- Capability prioritization based on identified pain points.
- As is (AI) Operational Architecture on the prioritized capabilities.

Task 2: CCS

Task 2 consists in developing 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.

Task 2 is structured in Domain teams:

- Cross-cutting activities:
  - The Operational Design Team
  - The Architecture and Release Coordination Team
  - The Migration and Roadmap Team
- (Sub-)System Design activities:
  - The Traffic Control and Supervision Team
  - The Trackside Assets Control & Supervision Team
  - The Train Control and Supervision Team

  - The Transversal CCS Components Team
  - The Communications Team
  - The Computing Environment Team

During 2023, the following achievements were accomplished:

- Common business objectives and operational vision for CCS and TMS.
- Harmonisation concepts for 12 of 31 areas of operational processes.
- Principles about the future harmonisation process, including about harmonisation granularity.
- Logical architecture and modularity of the vehicle CCS onboard units.
- High level requirements and basic logical architecture of the advanced CCS trackside systems.
- Working hypothesis for the design of the future moving block approach.
- Potential harmonized API for decoupling of hardware, operating systems, and software.
- First educated draft for a harmonized CCS/TMS data model for interface exchange objects.
- Basic rules for secure component specification.
- Functional scope of driver assistance systems.
- Flexible aggregation of trackside and onboard sensor information for occupation detection.

Task 3: Traffic management System/Capacity Management Design Team

Task 3 consists in developing the operational concept(s) and functional system architecture for the Traffic Management System and Capacity

Management System. Task 3 is structured around the Traffic Management Team, handling both cross-cutting activities and (Sub-) System Design activities.

During 2023, the following achievements were accomplished:

• Common business objectives and operational vision for CCS and TMS.

• Traffic Management System Concept.

• Functional allocation for the major CCS and TMS logical components.

Task 4: Digital automated coupling (DAC), Full Digital Freight Train Operations (FTDFTO)

Task 4 consists in developing the operational concept(s) and functional system architecture for the Digital Automated Coupling (DAC)/ Full Digital Freight Train Operations (FTDFTO). Task 4 is structured around the Traffic Management Team, handling both cross-cutting activities and (Sub-) System Design activities.

During 2023, the following achievements were accomplished:

• High level requirements for digital coupling concerning integrity and train length.

• Analyses for Central Instance.

• Beginning the development of the EU Harmonised Operation Procedures (FDFTO Rule Book).

• Operations Architecture related to FDFTO interfaces.

• Train-internal DAC/FDFTO Interface Analysis.

• Central Instance Management of data & software (updates).

The **highlights** among all the outcomes in 2023 were:

Standardisation and TSI Input plan (STIP)

The Standardisation and TSI Input Plan (STIP) shall facilitate the transfer of R&I results of EU-RAIL to the EU standardisation and regulation process, supporting the harmonised introduction of improvements into the European rail system. The process of a strategic alignment and collaboration between EU-RAIL and the TSI revision and European standardisation process has been developed. The first draft of the Standardisation and TSI Input Plan (STIP) has been published for review. It collects the topic proposals for harmonisation from the System Pillar and Innovation Pillar projects.

System pillar FRMCS V2 report

The report outlines a transparent and formalised process to align the FRMCS programme with the broader sector, DG, MOVE, ERA and EU-RAIL. It describes the scope, content and planning of the FRMCS V2 specifications, which will form the basis for an industrial European trial.

Subset of the EULYNX specifications B4R2 was endorsed as SP document.

EU-RAIL and EULYNX have published a common documentation release EULYNX Baseline Set 4 Release 2, bringing a part of the EULYNX development under technical authority of the EU-RAIL System Pillar. The published specifications, related to trackside assets and transversal functions, are applicable for both the current EULYNX architecture and the future European target architecture.

Architecture: Granularity Concepts and Principles. Guide on harmonisation granularity endorsed

The granularity, i.e. the extent to which modularization shall be performed in the system, is a main requirement for defining a rail target architecture and an approach to harmonisation. The degree of modularisation

determines the size and number of interfaces to harmonise and therefore the architecture. Guidance on the adequate approach for modularity and the creation of harmonised interfaces has been delivered.

CCS/TMS Data model

That to support the development and harmonisation of approach to the future development of the CCS (and interface to TMS) systems based on radio-based ETCS-only deployment, it is necessary to have a shared data language applied at all relevant interfaces with similar exchange items. The CCS/TMS Data Model aligns the data structures that are to be used on the relevant interfaces (for example communication, maintenance, diagnostics). A first draft of the Data model was presented.

The Innovation Pillar

The Innovation Pillar is set up to deliver user-focused research, innovation, and large-scale demonstrations. It is tasked to deliver the operational and technological solutions which provide the necessary capabilities to transform the European rail system. Its activities are organised in seven FAs and the Transversal Topic.

In 2023, as a result of the conclusion of the grant agreements in December 2022, the first six FAs and transversal topics have been covered by a first year of activities.

Eight new grant agreements were signed related to projects covering FA7 on innovation, new approaches for guided transport modes, and the "Exploratory Research and other activities", which started their R&I activities in 2023.

Additionally, EU-Rail launched a new call for proposals for "Exploratory Research and other activities" anticipating some activities related to FA1 on traffic management and synergies with the aviation sector. This latter topic is the first ever synergy topics call across JUs, which was achieved in coordination with SESAR 3 JU under EU-Rail call 2023-1 launched in October 2023. This call is still under evaluation, as planned, at the time of publication.

The preparation of call 2024-1, launched already in January 2024, has been another significant addition to the Innovation Pillar output anticipation. In 2023, EU-

Rail has planned new call topics on the FA on Digital & Automated up to Autonomous Train Operations and on the FA Sustainable Competitive Digital Green Rail Freight Services.

Another new synergy topic call has been set up (the second ever across JUs) together with SNS JU for the next EU-rail communication system using 5G technologies to ensure attractive, innovative, and tailor-made rail services. The next EU-rail communication system will be a key enabler for further innovation that has been added in 2023 to the EU-Rail programme, building on activities previously performed within different organisations outside EU governance.

This additional effort is expected to lead to a faster increase in competitiveness and attractiveness of the rail sector and its European industries worldwide. Furthermore, it will contribute to delivering upon the EU policy expectations.

Finally, EU-Rail continued to support disruptive innovations in the preparation of call 2024-1 with the launch of a topic covering new approaches for guided transport modes, such as hyperloop.

Network Management Planning and Control & Mobility Management

The main objective of Flagship Area 1 (FA1) is to provide solutions to dramatically improve flexibility, efficiency, resilience, and capacity adaptation of the European rail network, and enabling the development and operation of a Single European Rail Area.

FP1-MOTIONAL is the first project implementing FA1 and aims at contributing to this objective through the development of functional requirements, associated specifications, and operational and technological solutions to enable a future ERTMS that will make rail the backbone of a multimodal transport system for passengers and freight. This project is being delivered in two Workstreams (WS). On the one hand, WS1 deals with the planning and operations of the European Traffic Management and the integration activities of the rail services with the door-to-door mobility. On the other hand, WS2 works on the digital enablers (Transversal Topics) for all EU-Rail's destinations.

The work of EU-Rail in 2023 focused mostly on WS 1, specifically on WS 1.1: Capacity Management (planning), WS 1.2: Traffic Management (operations), and WS 1.3: Integration of rail traffic with door-to-door mobility.

In 2023, WS 1.1 delivered high-level user cases, requirements and the identification and high-level demonstrators required for the Capacity Planning, as well as simulation methods, models and feedback loops between Capacity planning and Traffic Management System (TMS), and TMS – Automatic Train Operation system (ATO)/Connected Driver Advisory System (C-DAS).

WS1.2's progress and results included the development of the requirements and of 17 high-level use cases and demonstrators for the TMS taking into consideration the links of the latter with ATO/C-DAS. These deliverables also considered a Reference Control, Command and Signalling Architecture, a Conceptual Data model and an Integration Layer, as elements of the future architecture of the TMS supporting a SERA.

Finally, WS1.3's progress includes the high-level architecture, requirements, and identification of 54 use cases for the integration of rail traffic with the door-to-door mobility.

Digital & Automated up to Autonomous Train Operations

Flagship Area 2 (FA2), which is implemented via the Flagship Project 2-R2DATO (FP2) in the first stage, focuses on leveraging digitalization and automation in rail operations, including the next generation Automatic Train Control (ATC) and Automated Train Operation (ATO) at Grade of Automation (GoA) 4 building upon radio based ERTMS or above. It aims to deliver scalable automation in train operations with fully unattended train operations, encompassing tasks such as setting a train in motion, driving, and stopping the train, opening and closing the doors, and remote train control and recovery operations in the event of disruptions. Most of the clusters within this project are consolidating and building upon the results of the S2R programme.

The Automation Processes Cluster (APC) established a foundation for the upcoming implementation of the Technical Enablers

 (TE1 – Automating Functions, TE4 – ATO Technology, TE6 – Perception, including the data factory, and TE7 – Remote Driving) which are core technologies required for the automatization of the railway operations. Use Cases creating the foundation for the demonstration in FP2, FP5 and FP6 have been defined, taking over the specification and modelling baseline from the S2R programme for GoA3/4 technologies.

The Optimized Headway Cluster (OHW) worked on requirements, use cases and technical enablers related to Hybrid Level 3, ETCS L3 moving block, train positioning, integrity, length and reproducible braking performance under low adhesion conditions. It worth mentioning the continuous collaboration with EUSPA

and ESA to explore the use of European Geostationary Navigation Overlay Service (EGNOS) applications.

The Digital Enabling Technologies Cluster progressed in developing and validating prototypes related to connectivity (both for train-to-ground communication and onboard communications), modular IT platforms, and the Digital Register as the single source of data truth for the railway system. These results are complemented by studies and specific concepts of how the modular connectivity, IT and data platforms can be efficiently integrated, certified, and driven toward acceptance. Same as for the other clusters of FP1, the basis of the work will be to consolidate prior work, further derive the requirements of future rail operation toward connectivity, IT and data platforms, and define related platform architectures in collaboration with the System Pillar.

Within the Fast and Effective Deployment Cluster, a business case for Digital & Automated Train Operations (DATO) was outlined, necessitating collaboration across TEs in FP2 as well as with FP1-MOTIONAL.For this purpose a collaboration map has been laid out including the necessary exchange points. Testing and validation efforts included knowledge transfer from Shift2Rail and implementing two test benches for virtual certification.

The Innovative Operational Solutions Cluster is looking at specific use cases where a further innovation beyond the GoA4 will bring additional value. This includes the Autonomous Route Setting (AnRS), that will realize the autonomous path allocation on a technical level and help increasing the capacity on the network, and

the Virtually Coupled Train Set (VCTS), that is required for the steady state of operating virtually coupled train sets and the Self-Driving Freight Wagon, that will enable autonomous operations of single wagons. A first version of use case for Self-Driving Freight Wagons is available.

All demonstrators foreseen in FP2-R2DATO have started the activities aligning with the technical enablers needed for the demonstration. With respect to Moving Block demonstration, a release plan for the demonstrator describing the stepwise demonstration of the new technology and the goals to be achieved with the demonstration has been created. Additionally, Demo 3 Urban has delivered the necessary use cases, the tramway modification report, and summarized the lessons learned on the approval process for automated tramways. Finally, The Onboard Platform demonstrator has been specified in close collaboration with the Enabling Digital Technologies Cluster.

Intelligent & Integrated Asset Management

The Flagship Area 3 (FA3), is implemented by Flagship Project 3-IAM4RAIL (FP3) in the initial phase, and its main objective is to provide new innovative technical requirements, methods, solutions and services 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 and availability and capacity of the railway system, addressing both infrastructure and rolling stock.

During 2023, activities of Sub-Area 1 on Wayside Monitoring and TMS link centred on delineating the architecture and requirements for data platform and KPIs for validation process. The development of the Intelligent Asset Management System (IAMS) architecture was a key achievement designed to serve both wayside and onboard systems. Ultimately supporting all FP3 sub-areas and ensuring data interoperability and sharing. Upcoming use cases in Italy and Spain will demonstrate the practical implementation of this system. Finally, alignment activities with FA1 have been initiated and will continue during the course of the project with the main objective to define common methodologies and best practices regarding the interconnected topics of Traffic Management System as well as Decision Support System.

The activities of Sub-Area 2 on Rolling Stock Asset Management related to the description of the vision of future European Railway Checkpoints from a holistic point of view in alignment with FA5. This included mapping technologies for both infrastructure and onboard systems. A significant agreement was reached on utilizing existing rolling stock sensor data for inspections and anomaly detection, particularly for key subsystems like Bogie and Traction. However, no final alignment was reached with FA5 on the exploitation of Condition-Based Maintenance (CBM) algorithms, with ongoing efforts to standardize methodologies and data sharing across European Railway Checkpoints.

In 2023, Sub-Area 3 on Infrastructure Asset Management conducted research to establish the current state of the art within defined use cases, considering technological advancements and industry trends. This understanding serves as a foundation for defining KPIs to effectively measure the proposed methodologies, algorithms, and technologies' effectiveness. Furthermore, experimental work, field tests, sensor installations in the field, and other activities have been carried out in demonstration campaigns across multiple countries, including Germany, Sweden, Spain, The Netherlands, and France.

In the course of 2023, Sub-Area 4 on Railway Digital Twins saw the establishment of technical management structures within designated areas, accompanied by the facilitation of administrative support for partners. Proactive measures were also implemented to establish and exploit connections with other FPs. Regarding the development of methods to exploit the Digital Twin of a station, the BIM model of the Malaga Zambrano station has been made available which will serve as a base for future research. Regarding the methods to use Digital Twin as integral part of a Virtual Certification Framework of the railway infrastructure, the overall conceptual framework and the related technical enabler have been defined.

Finally, Sub-Area 5: Environment, User and Worker Friendly Railway Assets has defined main guidelines, common tools, and methodologies for ecosystem development. These efforts are instrumental in setting the trajectory for subsequent innovations, aligning with the overarching objective of creating a sustainable, user-friendly, and technologically advanced railway. More specifically, final requirements and specifications list to successfully develop Augmented Reality (AR) and Exoskeleton solutions for railways maintenance operations have been issued. Additionally, regarding the development of the major common components, agreement has been reached on the use of ROS2 as middleware after a 2-stage study.

FLAGSHIP AREA 4

A Sustainable and Green Rail System

The main objective of Flagship Area 4 (FA4) is to provide 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. In the first phase of the programme, FA4 is implemented via FP4-Rail4EARTH.

During 2023, progress has been made and valuable results have been achieved on the different topics within Sub-Area 1: Alternative (to Diesel) Energy Solutions for the Rolling Stock, ranging from the finalization of the general requirements for the next generation of European BEMUs, to the definition of almost all the requirements for the ESS and the external power supply. Moreover, the charging power has been agreed among all the consortium partners and substantial work on traction chain requirements and the design of components has been achieved. Furthermore, the first tests of the battery cells have started. Regarding hydrogen technology, different systems for improving the efficiency of a hydrogen power plant were identified and the complete characterization of a hydrogen power plant is currently on-going.

Sub-Area 2: Energy in Rail Infrastructure and Stations has defined use cases for the double-sided feeding of 50 Hz AC traction substations using a flexible alternating current transmission system and consolidated a first version of the Railway Interline Power Flow Converter requirements. Additionally, the first draft requirements for the battery ESS

(Energy storage solution) were prepared and an ad hoc container for the battery system was designed. Based on the performed analysis, the most suitable technology for the onboard ESS to be developed for the large range BEMU demonstrator is the Lithium Ferrum Phosphate (battery). Finally, the first 3D models of architectural concepts have been prepared in preparation of the building of a modular low-emission station.

Sub-area 3: Sustainability and Resilience of the Rail System tackled several technical topics in different knowledge areas, including alternative drive systems, energy management, noise and vibrations, and wider topics like adaptation to climate change. The studies on the noise and vibrations topic have progressed by adapting the Railway Track Vibration Emission model for ground-borne vibration calculation in the time domain. This modelling theoretical approach was complemented by more practical results: the compiling of data from various inputs to establish a ground-borne vibration mitigation measures catalogue and the creation of an overview of existing gabion walls alongside the German tracks.

Sub-area 4: Electro-Mechanical Components and Sub-Systems for the Rolling Stock studied the of existing maturity of the electromechanical subsystems justifying the achievement of TRL4 and TRL6. Additionally, first studies addressing the theme of optimized motors and gearboxes, high performance bogies, suspensions, and new materials were caried out in 2023. Finally, aerodynamics numerical methods were enhanced and the preparation of wind tunnel tests with the generic model have been completed.

During 2023, substantial progress has been made in Sub-area 5: Healthier and Safer rail System. To complete the evaluation of the new technologies for the different ventilation concepts, the first test protocols for laboratory level tests were proposed and the discussion for the further levels (i.e., mock-up level and train level) has started. Furthermore, measurement scenarios have been defined to measure of air quality on covered platforms and tunnels and the first experiments in an underground station to assess an air treatment technology have begun.

Under Sub-area 6 on Trains Attractiveness (Interiors) a method finding the right path to reach innovative solutions in a given domain was developed. Concerning the modularity of interiors new opportunities and challenges for modularity were identified, taking into account the work already done under the S2R programme. Additionally, a preliminary literature study on the possibilities of biomimicry for circular and modular train interiors revealed the biomimicry potential of each challenge.
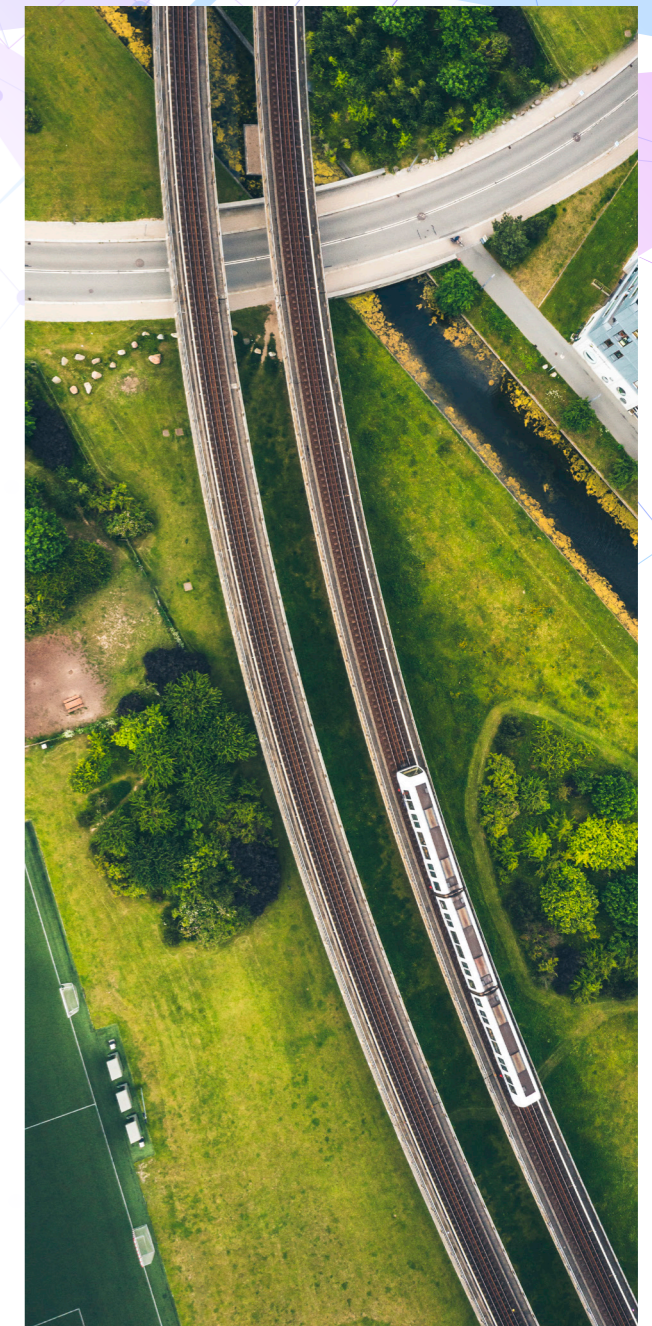
# Sustainable Competitive Digital Green Rail Freight Services

The objective of FA5, implemented via the FP5-TRANS4M-R In the first phase of the programme, is to make rail freight more attractive through increased capacity, e.g., with the DAC. FA5 has two clusters which are interlinked. The first one is "Full Digital Rail Freight Operations", focused on increasing substantially the productivity, quality and capacity of rail freight by applying digitalisation and automation to all possible operational functions and processes including innovative freight assets. The second one, "Seamless Rail Freight", is focused 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 in the long term combined with short/medium-term achievements and quick wins.

Since the beginning of the activities, the project has made significant strides in advancing the Future Digital Freight Train Operation (FDFTO) within the European rail freight sector. As a first step, target operational procedures for FDFTO have been developed and aligned within FP5 and with the System Pillar. Several Sounding Boards with further stakeholders from the EDDP have been held in 2023 to ensure dissemination and input throughout the European rail freight sector. The opening of the Train Test Lab in September 2023 represented a major step forward, marking a fourfold action plan that focuses on accelerating the development process through trial and error, deciding on component types, conducting approval-relevant tests, and implementing demonstrations. Since its conception, several tests have been successfully conducted in the Train Test Lab. Additionally, FP5-TRANS4M-R executed interoperability tests for the DAC by 2023-year end. For the execution of the tests,

all DAC-suppliers delivered prototypes to a laboratory in Budapest, where the interoperability tests have been executed according to the DAC test specifications.

In 2023 based on the target operational procedures, risk assessment and system architecture, the technical specifications for the DAC subsystems, hybrid coupler and yard automation have been finalised.

In 2023, progress has also been made in initiating work related to the Seamless Freight cluster. Specifically, the focus has been on delivering the essential functional and technical specifications required for the realisation of the technical enablers of Seamless Freight. A comprehensive report detailing the fundamental functional and technical specifications necessary to bring about the technical enablers of Seamless Freight has been delivered. Furthermore, in 2023 the definition, preparation of use cases and allocation of KPI reference values for future demonstrations was achieved, in close alignment with FP1. The requirements towards general principles of data sharing were used to include and adapt a Common Data Model. This heavily supports the standardisation activities of the European Checkpoints (including Intelligent Video Gate).
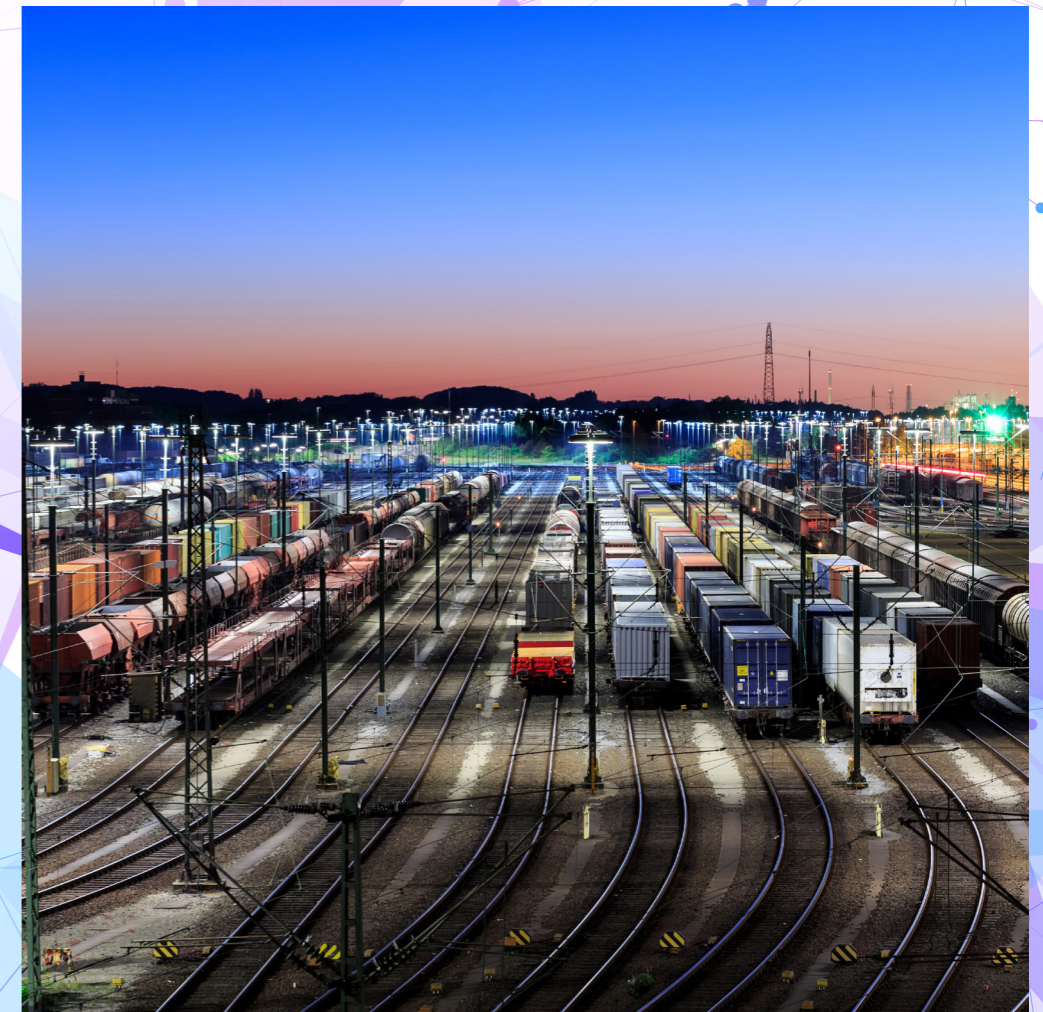
Regional rail services/ Innovative rail services to revitalise capillary lines

Flagship Area 6 (FA6) is dedicated to ensuring the long-term sustainability of regional railways by significantly reducing the Total Cost of Ownership (TCO), encompassing both operational and capital expenditures, while simultaneously enhancing service quality and operational safety. The initiative aims to make rail transport a more attractive and preferred option by leveraging digitalisation, automation, and emerging technologies across signalling, trackside components, rolling stock, and customer information systems. In 2023, FA6, implemented through the FP6-FutuRe project, achieved key milestones across its sub-areas:

Sub-Area 1 focusing on Regional Rail System Solutions/ Architecture developed a comprehensive regional rail architecture and defined operational and functional requirements, addressing both lines covered in the Interoperability Directive 2016/797/EU (Group 1) and lines which are not functionally/operationally connected to the mainline network (Group 2). This work laid the foundation for prototype development by establishing a shared framework with relevant Flagship Projects and the System Pillar. The sub-area also developed a set of KPIs linked to the technology enablers.

Sub-Area 2 looking at Command, Control, and Signalling & Operations identified and developed multiple use cases to support the creation of a European regional rail framework characterised by green, digital, safe, and cost-efficient solutions. Key areas of focus included ATO, remote driving, preliminary analysis of possible measures for the simplification of infrastructure deployment in the context of ETCS L2, conflict resolution using A.

Furthermore, activities performed so far focus on a preliminary assessment of a more accurate ETCS odometry and use of alternative virtual/physical reference points different from physical Eurobalises. Studies for the introduction of Train Integrity and Train Length for the use of new signalling systems that go beyond ETCS L2 were carried out.

Regional Rail Infrastructure Assets Sub Area 3 advanced the development of innovative infrastructure solution specifications, and the solutions themselves emphasising cost savings and safety improvements. Collaboration with European projects like C-Roads highlighted the potential of wireless technology for enhancing safety at railway crossings, particularly in remote areas. Detailed specifications for future infrastructure, including wireless communication, power management, maintenance as well as benchmarking were also established. In the area of communication, architecture, functional requirements and use cases were established. The work on SWOC provides the use cases, the first draft of architecture and interfaces as well as life cycle cost studies and exploitation model.

Addressing Regional Rail Rolling Stock, Sub Area 4 looked at the potential of a novel, lightweight, emission-free regional vehicle concept, with significant focus on reducing both capital and operational costs. A database of existing regional vehicles was compiled, and detailed draft requirements for the new vehicle design were produced, setting the basis for further development and optimisation. A propulsion chain model has been developed to compare various propulsion options and select the optimal one. Collaboration with FP4-Rail4EARTH on fuelling

stations is ongoing, where Sub-area 4 is defining key data on hydrogen refilling stations to optimize parameters like pressure and flow rate. Additionally, initial requirements for the vehicle-centric CCS for G2 have been drafted and shared with Sub-Area 1, with further studies needed to refine these requirements.

The focus of Sub-area 5 is to provide customer services concentrated on development and consequent demonstrations of highly accurate multimodal travel solutions. This sub-area made progress in defining specifications for enhanced customer services, including the integration of Demand Responsive Transport (DRT) with journey planning systems and improving accessibility for passengers with reduced mobility. The sub-area also worked on predicting travel demand and monitoring passenger congestion, with the goal of improving overall service efficiency and user experience. The sub-area has elaborated on the collaboration between FP1-MOTIONAL, as well as the System Pillar.

Innovation on new approaches for guided transport modes

Flagship Area 7 (FA7) focuses on exploring innovative, non-traditional, and high-speed guided transport systems. The goal is to integrate these new systems into existing rail networks to achieve socio-economic efficiency and sustainability across Europe. In 2023 the following projects contributed to this FA:

The **MaDe4Rail** project aims to explore non-traditional and emerging maglev-derived systems (MDS) and to evaluate the technical feasibility and effectiveness to introduce MDS in Europe. Benchmarking of existing traditional magnetic levitation systems and maglev-derived technologies was carried out. Definition of a common architecture and specification of the subsystems and technologies needed for its commercialisation have been performed to define the vehicle subsystem, identify the different interfaces between the vehicle and infrastructure, and provide a list of requirements and technical specifications for the different configurations of MDS. Furthermore, the first results also supported the definition of the different

use cases considering the different configurations identified and analysed through the Technology Readiness Assessment and Multi-Criteria Analysis.

The **POD4Rail** project aims at developing a concept for pods and pods carriers on railway in to adapt rail transport better to the users demand by providing higher flexibility and efficiency as well as realising on-demand transport.. In 2023, the project laid down the basis for the development of such a concept by setting set a common understanding of the system and the main components as well as describing the technical and operational requirements. A benchmarking exercise on existing Pod systems was carried out with a particular focus on rail-compatible solutions together with an assessment of these systems, based on a set of characterisation parameters defined by the partners. In addition, analysis on user acceptance aspects of a potential future Pod system as well as on the normative and legal framework were conducted.

Digital Enablers

The goal of «Digital Enablers» is to introduce new digital capabilities across EU-RAIL Work Programme destinations to support railway industry operations through:

- **Digital Twins (DT):** Utilizing reusable, interoperable model units in a federated simulation environment for analysis, such as root-cause detection.

- **Digital Twin Design Toolbox:** Tools for modeling, validation, and interoperability.

- **Federated Rail Dataspace Sandpit:** Facilitating data exchange with a common ontology, identity management, and cybersecurity.

In 2023 Federated Data Space Developed a compliant Rail Data Space sandbox environment, enabling secure data sharing across 35 identified and prioritized use cases. Demonstrated IDSA compliance, ensuring integration with the Common European mobility data space. Provided input on Rail Data Space governance and architecture for the System Pillar.

In 2023 Common Domain Ontology Identified CDM use cases and modeling requirements across various projects. Assessed and improved CDM concepts related to Topology and Geometry, supporting System Pillar initiatives. Explored serialization approaches for transforming proprietary data into CDM-compatible formats.

In 2023 Digital Assets Engineering Identified and synchronized interactions across FP1-MOTIONAL and other Flagship projects. Developed a Use Case repository populated with data from multiple projects.

In 2023 Digital Twin Support, Development, and Run-Time Environment Analyzed use cases, including ETCS Digital Twin, braking systems, and fault detection. Implemented a pilot Functional Mock-Up (FMU) of rail infrastructure, enabling simulation of train operations in a web-based environment.

Exploratory Research

The Academics4Rail project aims to build a stable and durable community of railway scientific researchers and academia to share and exchange scientific knowledge with Europe's Rail, as well as to enable a network of PhDs (with the academia teaming up with the industry) on a set of topics,

In 2023, all the 6 PhD positions have been filled in and the students have advanced positively through the state of the art on their respective areas. Moreover, the foundations for the establishment of a scientific community have been set. A screening activity for the funding for railway research in Europe has also been performed and information on current railway projects has been gathered in a database. Finally, the first steps towards the development of an overarching framework and methodology for the qualitative and quantitative assessment of Europe's Rail societal KPIs have been covered.

The InBridge4EU project addresses unresolved issues in current railway infrastructure standards, focusing on improving the dynamic interface between railway bridges and rolling stock. During 2023, the project has acquired information on passenger train data to build a database of vehicle parameters and train configurations. Also, the project has selected 9 railway lines from 5 EU countries from which representative bridges will be analysed. The consortium laid the grounds for the study of the dynamic factors ϕ' and ϕ'' and experimental data from different bridges in Europe has been collected to estimate damping coefficients from the respective free vibration periods. A review of previous research in ballast behaviour has

been conducted and insights the topic of dynamically excited ballasted tracks bridges is being collected. Finally, FEM models of the case study non-ballasted bridges have been partially developed and the train-bridge interaction analysis already started.

The RAIL4CITIES project aims to transform railway stations into promoters of sustainable cities. It focuses on developing a new operational model (SCP model) and deploying it across five European living labs, each targeting different aspects of station transformation. In 2023, the project has introduced a new operational model for stations as sustainable city promoters (SCP), including the underlying theoretical considerations that led to its development. Furthermore, an outlook is provided on how this proposed model will later be corroborated with data from the five living labs situated in France, Italy, Germany, Poland, Belgium, and three additional case studies in Portugal, testing specifically how railway stations can play a substantial role in sustainable urban development.

ESEP4FREIGHT has focused on data collection, innovation assessments, and freight flow analysis to evaluate and enhance freight technologies like digital automatic couplers and intelligent video gates. The main activities have been carried out on data collection, innovation assessments and analysis of freight flows. The project has been working on identifying the stakeholder group is expected to validate the final set of KPIs. A work plan and the draft framework for the evaluation of innovative technologies were developed, and the results of the evaluation of the digital automatic coupler (DAC)

and intelligent video gates (IVGs) showed that the time required for train handling in the terminals is lower. A work plan was developed for analysis of the freight market trends and freight. Furthermore, a draft conceptual framework and potential architecture for intermodal transport using blockchain technologies and smart contracts was developed.

LEADER2030 aims to address the future availability of raw materials and components for EU-Rail innovations by 2030. In 2023, a European survey revealed significant expected increases in demand for key materials like chips, aluminium, and copper, highlighting potential supply challenges that could impact the digitalisation and greening of European railways.

As a support action, DACcord coordinated efforts related to the European DAC Delivery programme. The project updated the DAC General Master Plan, developed a roadmap for DAC migration, and coordinated a cost-benefit analysis. Key milestones included a DAC basic package decision for future deployment and the signing of a DAC Sector Statement by 50 companies, emphasising DAC's importance in rail freight modernisation

The European DAC Delivery Programme Under the Leadership of EU-Rail

In July 2020, the GB of the JU endorsed the creation of the EDDP proposed by the ED, voicing the request on behalf of the railway sector. Building upon the outcomes achieved in S2R's freight related R&I activities in IP 5, this programme brings together the rail sector beyond the membership to bridge the research work with innovation, including migration planning, towards the deployment of a European DAC solution built on open and transparent standard specifications. This activity constitutes a major step towards digital rail freight, enabling new operations and services that will contribute to meeting the expectations of the Sustainable and Smart Mobility Strategy of the Commission.

Through an independently managed delivery programme, the EDDP integrates projects like DAC4EU, funded by the German Federal Ministry of Transport and Digital Infrastructure, as well as relevant results from S2R projects under IP5 on European rail freight.

The following was achieved:

- The EDDP participation continuously increased, counting on more than 300 experts and more than 80 companies and organisation involved across Europe and beyond,

- DAC target operational procedures for the first DAC use cases are ready,

EU-Rail FP5-TRANS4M-R (2022-2026) started its activities with 27 beneficiaries and 71 partners in order to achieve:

- ◦ The DAC specification for "mechanical/ pneumatical", "energy" and "communication",

- ◦ The demonstration of Digital Freight Trains in 2025 with DAC Type 4 & 5 including energy and data supply, hybrid coupler, and automated brake test (at TRL 8),

- ◦ Preparing further development of a Full Digital Freight Train for future demos.

- Operational DAC tests taking place in European countries,

- The development of solid and feasible migration scenarios, for the first time in Europe,

- A first iteration of the CBA was performed under the leadership of the Commission, supported by the previous life cycle cost analysis commissioned by EU-Rail,

- EU-Rail contracted the company EY to create and finalise a first European investment plan in early 2023 setting the basis for further steps for the DAC-implementation and deployment strategy.[10]

In 2023, several meetings continued with the ERA DAC Topical Working Group with the aim to agree on a DAC spec that could be adopted in a future TSI, supporting harmonisation all across EU rail network.

In 2023, the DACcord Coordination and Support Action supported the running of EDDP through stakeholder management and worked on the DAC migration roadmap. The main achievement was the development of the revised DAC General Master Plan 01, taking into account all recent evolutions and insights, and incorporating them into a large-scale testing phase of around 100 trains before embarking on a fully fledged DAC roll-out. An updated DAC CBA was coordinated in EDDP and led by the Commission, followed by the creation of a task force on intermodal traffic with stakeholders from Intermodal and EDDP to better reflect intermodal aspects in the CBA. This WP permanently interacted with all other DACCord WPs and with FP5. A regular cross-coordination of the works of the EDDP, FP5, and the EU-Rail System Pillar (Task 4) was implemented.

Furthermore, the project supported the work of the migration roadmap update, especially on the collection of the European vehicle fleet data. A major milestone was the coordination and decision on the so called "DAC basic package" in September and November 2023. This package defines the DAC and DAC applications that FP5 will deliver by 2025/2026 for test in the pre-deployment trains and later for the full deployment.

Additionally, the project coordinated a "DAC Sector Statement" (taking into account the new Master Plan) in the first half of 2023, which was signed by 50 companies and associations from the European rail freight sector and handed over from the sector to the Commission in July 2023.

The project also worked together with FP5 on setting-up three, so called, EU-Rail "sounding boards". The results of these sounding boards were reported to the EDDP programme board and used for evaluation by FP5.

DAC General Master Plan 01 [June 2023]
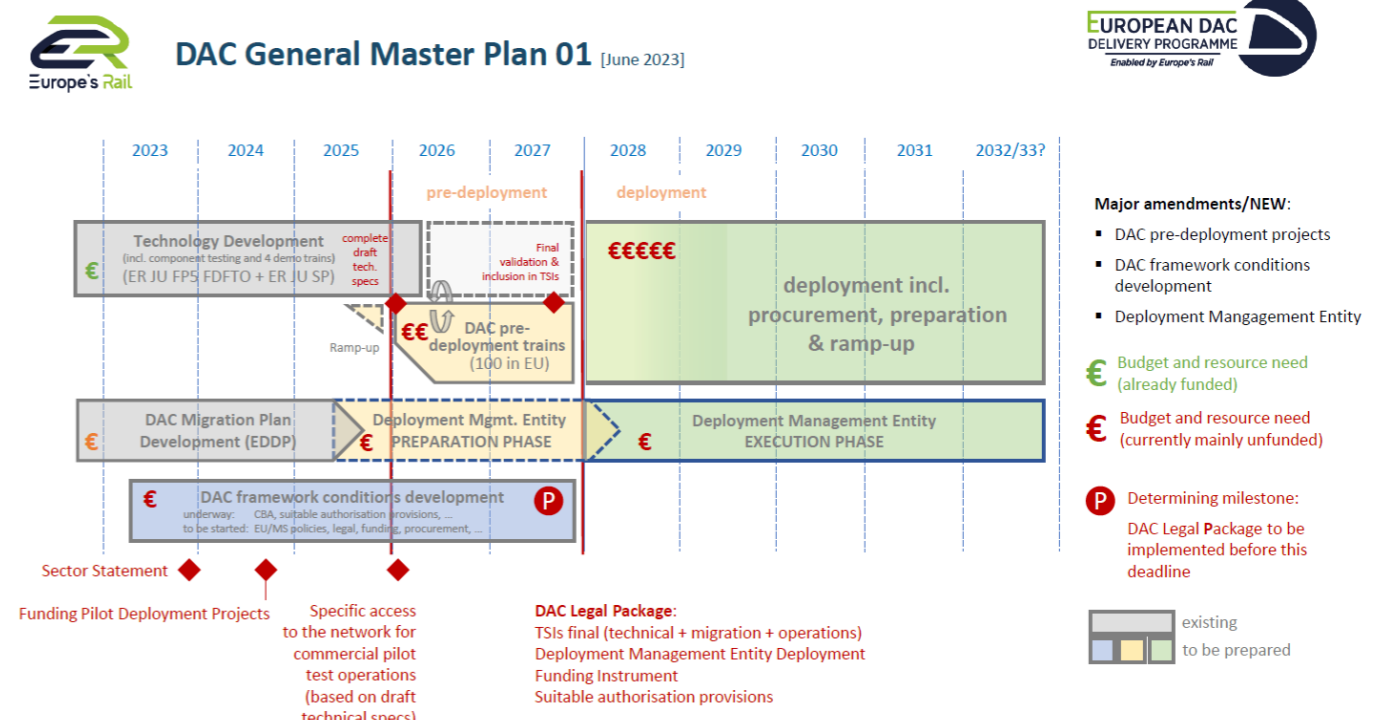
Other Activities

The EU-Rail Staff Establishment Plan, adopted by the GB on 1 March 2022, covers the EU-Rail activities of 2023 from the resources needs perspective.

In December 2023, the GB adopted the Staff Establishment Plan for 2024, introducing three staff members to the BOA, which covers accounting services for all JUs.

According to the Staff Establishment Plan applicable to 2023, EU-Rail should have been staffed with 29 staff members, including two Seconded National Experts (SNE). In 2023, the JU experienced four departures of staff members and the vacant posts were progressively filled. The ED post was covered ad interim in order to ensure business continuity while recruitment was ongoing. To fill temporary gaps or long-term absences, the JU also made use of external competencies and expertise as well as temporary outsourcing to achieve its operational activities as well as some administrative tasks.

With regard to the communication and dissemination activities, the focus was primarily on the supporting activities of EU-Rail with particular attention to the promotion of the new programme; its objectives and mission, the introduction of the role of the new System Pillar and the Deployment Group. At the same time, demonstration activities and dissemination of

relevant results for market uptake with regards to the ongoing and finished S2R projects were enhanced. The spotlight was also placed on the promotion of the objectives of the six new FPs, including the development of dedicated website areas and launching an in-depth article campaign describing the expected benefits of the projects.

Furthermore, project results were disseminated at the various events where EU-Rail participated, including at the UIC World Congress on High-Speed Rail, SIFER, Rail Transport Day, UITP Global Public Transport Summit, Space for Innovation in Rail, Rail Live, and during the Europe's Rail General Assembly (online), etc.

In addition to the efforts on stakeholder involvement, the JU further continued improving its internal organisation as to provide continuous support to its members and beneficiaries. Attention was paid to the continuous implementing of the internal control framework and to the assessment and management of risks. The JU cooperated with different stakeholders engaged in audit activities, such as the European Court of Auditors, the Internal Audit Service of the Commission, the Common Audit Service exercised by the Directorate-General for Research and Innovation (DG RTD) of the Commision or the external auditors auditing the Annual Accounts of the JU. All of these activities have contributed to the continuous assurance regarding the sound financial management of EU funds managed by the EU-Rail

In 2023, EU-Rail submitted a follow-up report to the European Parliament on the Parliament's observations provided in its resolution related to the decision on discharge in respect of the implementation of the JU's budget for the financial year 2021. In this follow-up report, the JU explained the way in which it addressed these observations or intends to address them in the upcoming period. More specifically, the repport elaborated, amongst other things, on how EU-Rail

contributes to the EU goals related to transport (e.g. in highspeed rail, carbon-neutrality of some types of collective travel, automated mobility, increasing the rail freight traffic, advanced levels of automation, etc.). In response to some HR-related issues that were pointed out by the Parliament, the JU clarified the objective conditions in which it operates and the feasible actions that it took or will take in that area. Furthermore, the JU confirmed how the deficiencies identified and reported by the Court of Auditors were addressed and provided an update on the fulfilment of the action plan tackling the outstanding recommendations following from the "Audit on H2020

grant implementation and closing" conducted by the Commission's Internal Audit Service.

It can be concluded that thanks to the commitment of both the EU-Rail members and the Programme Office, 2023 has seen the JU further continuing its important progress towards delivering both the S2R and EU-Rail programmes.

European Green Deal, the United Nations Sustainable Development Goals, the Sustainable and Smart Mobility Strategy and the Digital Decade

SDG 9: Building resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation
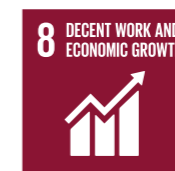
SDG 12: Ensure sustainable consumption and production patterns

SDG 13: Take urgent action to compact climate change and is impacts

SDG 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

SDG 5: Achieving gender equality and empower all women and girls

The European Green Deal was presented in December 2019, setting out a clear vision of how to achieve climate neutrality in Europe by 2050.[11] Transport accounts for a quarter of the EU's greenhouse gas emissions and this share is still growing. To achieve climate neutrality, a 90% reduction in transport emissions is needed by 2050. As a matter of priority, a substantial part of the 75% of inland freight carried today by road should shift onto rail and inland waterways.

"To transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use." (European Green Deal, p. 2).

Priority areas include accelerating the shift to sustainable and smart mobility: "Automated and connected multimodal mobility will play an increasing role, together with smart traffic management systems enabled by digitalisation. The EU transport system and infrastructure will be made fit to support new sustainable mobility services that can reduce congestion and pollution, especially in urban areas" (European Green Deal, p. 10).

In July 2021, the so-called "Fit for 55" package was introduced by the Commission.[12] The package consists of a set of inter-connected proposals making the existing legislation more ambitious where possible and even putting new proposals on the table where needed. The main ambition of the EU under this package is cutting emissions by at least 55% by 2030 by also supporting a faster roll-out, relative to prior objectives, of sustainable transport solutions such as rail. Overall, the package strengthens eight existing pieces of legislation and presents five new initiatives across a range of policy areas and economic sectors; climate, energy and fuels, transport, buildings, land use, and forestry.

The European Green Deal is also an integral part of the Commission's strategy to implement the United Nation's 2030 Agenda and the 17 Sustainable Development Goals (SDGs).[13] Already under the S2R programme in 2018, the JU has been reporting in its Consolidated Annual Activity Reports on its contribution to the SDGs. The JU, under its current programme, will continue this endeavour, to achieve the SDG's listed below specifically.[14]

More concrete insights into how EU-Rail aims to contribute to the broader objectives represented by the SDGs can be obtained from Annex E and Annex F, which provide information on the Key Performance Indicators/Key Impact Pathway Indicators. However, it should be noted that the precising of indicators for following-up on the EU-Rail programme under Horizon Europe was not yet finalised in 2022. This process will still continue in 2023.

Furthermore, the Sustainable and Smart Mobility Strategy of the Commission, launched in December 2020, includes more concrete milestones for the railway sector to enhance a smart and sustainable future.[15] Its underlying action plan, comprising 82 initiatives, lays the foundation for how the EU transport system can achieve a green and digital transformation and become more resilient to future crises. In particular, it provides the visionary ambitions that the next rail R&I programme will have to contribute to insofar as possible and notably:

- By 2030, the high-speed rail traffic will increase by 50% and the scheduled collective travel of under 500 km should be carbon neutral within the EU and automated mobility will be deployed at large scale.

- By 2050 rail freight traffic will double, high-speed rail traffic will triple, and the multimodal Trans-European Transport Network (TEN-T) will be equipped for sustainable and smart transport and operational for the comprehensive network with high-speed connectivity.

Additionally, rail transport will also need to be further electrified. Wherever this is not viable, the use of hydrogen should be increased. Furthermore, the roll out of the ERTMS will be pursued, including further efforts to develop train automation, for instance through JUs.

On the topic of the "Digital Decade", the Commission indicated in its communication of March 2021 how the digital transformation can improve the ecosystems related to mobility and transport.[16] Digitalisation can improve environmental and cost performance and, simultaneously, increase safety levels contributing to a higher quality of life. This 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. Passengers could also benefit from fast internet connectivity on most stations and lines, user-oriented telematics, and facilitated multi-modality.

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11   European Commission (2019). The European Green Deal. COM(2019) 640 final, Brussels
12   https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0550 and https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/
13   United Nations General Assembly (2015). Transforming Our World: The 2030 Agenda for Sustainable Development. Draft resolution referred to the United Nations summit for the adoption of the post-2015 development agenda by the General Assembly at its sixty-ninth session. UN Doc. A/70/L.1. New York
14   As also indicated in the Biennial Monitoring Report 2022 on Partnerships in Horizon Europe, page 295: https://op.europa.eu/en/publication-detail/-/publication/a6cbe152-d19e-11ec-a95f-01aa75ed71a1/language-en/format-PDF/source-search

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15   European Commission (2020). Sustainable and Smart Mobility Strategy – putting European transport on track for the future. COM(2020) 789 final, Brussels
16   European Commission (2021). 2030 Digital Compass: the European way for the Digital Decade. COM(2021) 118 final, Brussels

In this context, EU-Rail's programme strives for speeding up the development and deployment of innovative technologies in railway transport in order to contribute to the 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.

Besides the efforts made via its R&I programme, EU-Rail and its staff, to the extent corresponding to the size of the organisation, also strive to contribute to the fight against climate change when conducting the day-to-day business. As such, the JU has installed the following practices to be as green as possible include:

• Separating waste in the JU's premises,

• Suppression of single-use items,

• Reducing paper consumption by applying paperless workflows to the extent possible,

• Encouraging staff not to commute to work by car by providing a scheme for reimbursement of public transport cost and arrangements supporting commuting by bike,

• Increased usage of online/hybrid meetings and events to reduce the carbon footprint related to travelling.

While the option of moving office in 2022 or early 2023 was eventually not realised, any future decision-making of EU-Rail in this respect will include due considerations regarding the energy-efficiency parameters of the respective premises.

Flagship Projects

Topic Code	Topic Description	Project value € M	Partners Involved	Duration
HORIZON-ER-JU-2022-FA1-TT-01	Network management planning and control & Mobility Management in a multimodal environment and Digital Enablers	92.6	88	46 months
HORIZON-ER-JU-2022- FA2-01	Digital & Automated up to Autonomous Train Operations	160.8	76	42 months
HORIZON-ER-JU-2022- FA3-01	Intelligent & Integrated asset management	106.9	94	48 months
HORIZON-ER-JU-2022- FA4-01	A sustainable and green rail system	95.1	71	48 months
HORIZON-ER-JU-2022- FA5-01	Sustainable Competitive Digital Green Rail Freight Services	95.1	71	45 months
HORIZON-ER-JU-2022-FA6-01	Regional rail services/ Innovative rail services to revitalise capillary lines	32.9	50	48 months

Other Projects

Topic Code	Topic Description	Project value € M	Partners Involved	Duration
HORIZON-ER-JU-2022-FA7-01	Concept Development of a System for Pods and Pod-Carriers to be used as Moving Infrastructures mainly for Rail, but as well for Road and Ropeways	3	15	30 months
HORIZON-ER-JU-2022-ExplR-01	Railway stations for green and socially inclusive cities	0.7	14	24 months
HORIZON-ER-JU-2022-ExplR-02	Enhanced Interfaces and train categories for dynamic compatibility assessment of European railway bridges	0.9	11	36 months
HORIZON-ER-JU-2022-ExplR-03	European Shift Enabler Portal for Freight	1.3	9	24 months
HORIZON-ER-JU-2022-ExplR-04	Building a community of railway scientific researchers and academia for ERJU and enabling a network of PhDs (academia teaming with industry)	1.8	25	42 months
HORIZON-ER-JU-2022-ExplR-06	Learnings for European Autonomy to Deliver Europe's Rail in 2030	0.7	4	30 months
HORIZON-ER-JU-2022-ExplR-07	DAC migration roadmap towards deployment and related activities	1.5	6	36 months
HORIZON-ER-JU-2022-FA7-02	Maglev-Derived Systems for Rail	1.5	16	12 months

Europe's Rail Overview

Name	Europe's Rail Joint Undertaking – as of 30/11/2021
Objectives[17]	EU-Rail is an autonomous body with its own legal personality. It is an institutional European partnership as per Article 187 of the Treaty on the Functioning of the European Union[18] dedicated to managing and coordinating mission-oriented R&I activities for a major transformation in rail systems in Europe. The general objectives of EU-Rail are to: a. Contribute towards the achievement of the SERA, b. Ensure a fast transition to a 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 main task 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.
Legal basis	Article 187 of the Treaty on the Functioning of the European Union [19] The founding legal act of EU-Rail is the Council Regulation (EU) 2021/2085[20] of 19 November 2021, which entered into force on 30 November 2021, establishing the Joint Undertakings under Horizon Europe (hereafter the "Single Basic Act" or the "SBA"). By means of the SBA, the EU-Rail was established and became the legal and universal successor of the former S2R JU, which it replaced and succeeded as from that date. In addition, in its first meeting, the EU-Rail GB approved 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.[21]

Executive Director (ED)	Mr Carlo M. Borghini, until 28 February 2023.[22] Mr Giorgio Travaini, appointed ED ad interim as from 1 March 2023.[23]
Governing Board of EU-Rail	**European Commission (EC) members:** • Mr Henrik Hololei, DG MOVE, until 31 March 2023 • Ms Magda Kopczynska, DG MOVE

EC alternates:

• DG MOVE	Mr Kristian Schmidt
• DG RTD	Ms Rosalinde van der Vlies

Industry members:

• ADIF	Mr Luis Fernando López
• ALSTOM	Mr Nicolas Castres Saint Martin
• ANGELRAIL consortium led by MER MEC	Mr Francesco Inzirillo
• AŽD	Mr Vladimir Kampik
• CAF	Mr Jorge De Castro
• CEIT	Mr Juan Melendez
• ČD	Ms Tereza Kunertová
• DEUTSCHE BAHN	Mr Ralf Marxen
• DLR	Mr Christian Sattler
• eSGR JV	Ms Noemi Jimenez Redondo
• Faiveley Transport	Mr Roberto Tione
• Ferrovie dello Stato Italiane	Mr Roberto Tundo
• HITACHI RAIL STS	Ms Antonella Trombetta
• INDRA-TALGO	Mr Jose Miguel Rubio Sanchez
• Jernbanedirektorate	Mr Preben Saethre
• KNORR-BREMSE	Mr Hans-Christian Hilse
• ÖBB	Mr Mark Topal Goekceli
• PKP	Mr Jancewicz Zbigniew
• ProRail-NS Groep	Mr Karel van Gils
• SIEMENS	Mr Roland Edel
• SNCF	Mr Christophe Cheron
• Strukton	Mr Tjark de Vries
• THALES	Mr. Alberto Parrondo
• TRAFIKVERKET	Mr Bo Olsson
• Voestalpine Railway Systems	Mr Jochen Holzfeind

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17 The key objectives pertaining to the S2R Programme, pursued by the former Shift2Rail Joint Undertaking, and inherited by its successor, EU-Rail, are the following:
- a 50% reduction of the life-cycle cost of the railway transport system (i.e., costs of building, operating, maintaining and renewing infrastructure and rolling stock),
- a 100% increase in the capacity of the railway transport system,
- a 50% increase in the reliability and punctuality of rail services (measured as a 50% decrease in unreliability and late arrivals).

18 OJ C 202, 7.6.2016, p. 131–131
19 Ibid
20 OJ L 427, 30.11.2021
21 EU-Rail GB Decision n° 02/2021

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22 Based on the confirmation of early retirement of Mr Borghini by means of the EU-Rail GB Decision n° 01/2023.
23 Based on the EU-Rail GB Decision n° 02/2023.

Governing Board of EU-Rail	*Industry alternates:*
	• ADIF — Mr David-Ibán Villalmanzo Resusta
	• ALSTOM — Mr Richard French
	• ANGELRAIL consortium led by MER MEC — Mr Vincenzo Scarnera
	• AŽD — Mr Michal Pavel
	• CAF — Mr Imanol Iturrioz Villalba
	• CEIT — Mr Jaizki Mendizabal
	• ČD — Mr Petr Jindra - Mr Marek Zajic
	• DEUTSCHE BAHN — Mr Hans-Peter Lang
	• DLR — Mr Michael Meyer zu Hörste - Ms Svenja Hainz
	• eSGR JV — Mr David Sanz - Mr Jose Solis Hernandez — Mr Celestino Martinez
	• Faiveley Transport — Mr Paolo Pagliero
	• Ferrovie dello Stato Italiane — Mr Riccardo Santoro
	• HITACHI RAIL STS — Mr Carlo Crovetto
	• INDRA-TALGO — Mr Alfredo Gonzalez Moreno
	• Jernbanedirektorate — Mr Pal Midtlien Danielsen
	• KNORR-BREMSE — Mr Martin Ertl
	• ÖBB — Mr Bertram Ludwig
	• PKP — Mr Fojud Arthur
	• ProRail-NS Groep — Mr Jeroen Fukken
	• SIEMENS — Mr Lars Deiterding - Mr Ralf Kaminsky
	• SNCF — Mr Gilles Quesnel
	• Strukton — Mr Henk Samson
	• THALES — Mr Yves Perreal
	• TRAFIKVERKET — Mr Christer Lofving
	• Voestalpine Railway Systems — Mr Uwe Ossberger
	Other participants:
	• EU-Rail — Mr Giorgio Travaini
	Observers:
	• ERA — Mr Josef Doppelbauer — Ms Ana Gigantino — Ms Ny Tiana Tournier
	• ERRAC — Mr Roland Moser — Ms Marta Garcia
	• Scientific Committee (SC) — Ms Angela Di Febbraro
	• State's Representative Group (SRG) — Mr Miroslav Haltuf
Other bodies	• System Pillar Steering Group
	• Deployment Group
	• SRG
	• SSG
Number of staff	28 posts as at year-end 2023[24]

Total budget 2023	At the year-end of 2023, the JU had implemented 100% of its commitment appropriations made available in its active budget (Titles 1 to 4). The payment appropriations implemented up to 85.2% (79.1% in 2022) of the active funds [or 82.4% of implementation when compared to the full JU budget (including Title 5)].

By means of the GB Decision 14/2022 of 30 November,[25] the EU-Rail GB adopted the initial Annual Work Plan and Budget for 2023-2024.[26]

There were two amendments to this initial Decision adopted during 2023 having impact on the budget:

• **Amendment number 1:** This amendment recognised and balanced (Revenue and Expenditure) unused appropriations of the S2R programme operational expenditure due in relation to the previous budgetary years, in accordance with EU-Rail Financial Rules Article 6.5.[27]

Furthermore, in accordance with the SBA (recitals 10 and 12 and Article 5(2) c),[28] to achieve maximum impact, the joint undertakings should develop close synergies with other Horizon Europe initiatives and other Union programmes and funding instruments, particularly with those supporting the deployment of innovative solutions. Following the identification of synergies between them, joint undertakings should aim to determine budget shares which could be used to compliment joint activities between joint undertakings, including by dedicating, where appropriate, a part of the joint undertaking's budget to joint calls.

This occurred in 2023 when EU-Rail and SESAR 3 JU launched a joint topic call. As a result, EUR 2,500,000 was added to the section "EU Contribution" in accordance with the structure of the EU-Rail budget. However, these funds originated from SESAR 3 JU and not from the Union. In accordance with SBA Article 10.4, the EUR 2,500,000 of new revenue in 2023 is considered as additional Union funds complementing the contribution allocated to the EU-Rail programme implementing Horizon Europe. In this respect, and in accordance with SBA Article 10.6, this additional contribution from Union programmes corresponding to additional tasks entrusted to EU-Rail, shall not be accounted for in the calculation of the Union maximum financial contribution to the EU-Rail programme.

• **Amendment number 2:** The ED proposed to the GB an adaptation of the budget in order to recognise the addition of new assigned revenue (recovery from projects or administrative expenditure. As such, an adaptation of the budget appropriation (mainly in payment appropriations) per line was proposed, considering the evolution of budget needs and payment budget forecast until year-end, which was lower than planned, in particular for staff expenditure and associated costs (turnover in 2023).

As a result, the budget as finally adopted amounted to:
Commitment appropriations: EUR 102.6 million
Payment appropriations: EUR 120.3 million

Budget implementation	The implementation rate of the operational budget in commitment appropriations was 100% and 85% in payment appropriations (79% in 2022). In 2023, an important portion of payment appropriations was used for the second pre-financing of the grants resulting from the first 2022 call for proposal. Commitment appropriations total consumption: EUR 99.6 million – 100% Further breakdown by titles in EUR and in % of total, excluding unused appropriations: Title 1 – EUR 3.6 million – 100% Title 2 – EUR 1.4 million – 100% Title 3 - 4 – EUR 94.6 million – 100% Payment appropriations total consumption: EUR 99.1 million – 85% Further breakdown by titles in EUR and in % of total, excluding unused appropriations: Title 1 – EUR 3.0 million – 96% Title 2 – EUR 1.3 million – 95% Title 3 - 4 – EUR 94.8 million – 85% The reported implementation also includes payments to the Expert Evaluators which is managed by the European Research Executive Agenda (REA) Services. In 2023, the second instalment of the grant agreements derived from the first call of 2022 and the award of six FPs have been covered with complementary budget (commitment appropriations) and the payment of the second pre-financing. Additionally, in 2023 EU-Rail launched a third call, that included the joint synergy topic call with SESAR 3 JU as indicated in the section above.[29] For the S2R programme, the year 2023 mainly entailed ensuring the proper execution of ongoing activities. By the end of 2021, the JU had signed 101 grant agreements in total since its autonomy in 2016. With the Calls 2021 R&I activities up and running, the R&I activities performed in the programme will reach EUR 800 million (including Lighthouse Projects as part of the S2R initiative). Of this amount, EUR 649.5 million was performed by the S2R Other Members with a funding made available by the JU up to a maximum of EUR 303.3 million. At the end of 2023, 66 of the 101 S2R projects were closed. The S2R programme is continuing its phasing out as all technical activities were concluded by the end of December 2023, with the objective of overall closure of the programme by 2024, with the execution of all the final payments related to grant agreements.
Grants/ Tenders	The value of eight signed grants resulting from the second 2022 call corresponds to EUR 11.4 million of eligible costs and EUR 14.1 million of total project value that will be funded by EU-Rail for up to EUR 11.4 million.[30] In 2023, contracts/orders (legal commitments) amounting to EUR 24.8 million were signed, of which EUR 22.5 million resulted from operational procurements and EUR 2.2 million from administrative procurements.

Strategic Research & Innovation Agenda	In the context of EU-Rail, 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 SBA Article 86(5), the SRIA of EU-Rail is constituted by its Master Plan.[31]
Call imple- mentation	Number of calls launched in 2023: 1 Number of proposals submitted: 24 Number of evaluated proposals: 21 Number of proposals retained for funding: 7
Participation, including SMEs	Total number of beneficiaries in funded projects: 72 • 25% of which are Small and medium-sized enterprises (SME) receiving 19.2% of total EU funding provided by EU-Rail, • 36.1% of which are private for-profit companies receiving 33.20% of total EU funding provided by EU-Rail, • 2.7% of which are non-EU entities receiving 0.52% of total EU funding provided by EU-Rail. 31 SME participations were part of the evaluated proposals in the second 2022 call of which 16 SME participations were included in the proposals retained for funding.

29   At the time of publication, the joint synergy topic call with SESAR 3 JU is still under preparation.

30   The grants resulting from the second 2022 call were awarded in the course of 2023. The grants resulting from the 2023 call will be awarded in the course of 2024, hence, the grant agreement figures related to that call will be presented in section 1.5 the 2024 CAAR. However, the information about the evaluation procedure for the 2023 call is already provided in this CAAR.

31   https://rail-research.europa.eu/wp-content/uploads/2022/03/EURAIL_Master-Plan.pdf

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