Draft proposal for a

European Partnership under Horizon Europe

Transforming Europe's Rail System

Version 1 July 2020

Summary

Accelerate development and deployment of innovative technologies (especially digital and automation) and deliver on European Green Deal objectives (e.g. shift substantial part of the 75% of inland freight carried today by road to rail and inland waterways). Outputs would become a mandatory part of the target rail system. Develop solutions with broad support across EU–up to 75% market uptake by 2030, improving the competitiveness of rail and support the European technological leadership in rail.

About this draft

In autumn 2019 the Commission services asked potential partners to further elaborate proposals for the candidate European Partnerships identified during the strategic planning of Horizon Europe. These proposals have been developed by potential partners based on common guidance and template, taking into account the initial concepts developed by the Commission and feedback received from Member States during early consultation[1]. The Commission Services have guided revisions during drafting to facilitate alignment with the overall EU political ambition and compliance with the criteria for Partnerships.

This document is a stable draft of the partnership proposal, released for the purpose of ensuring transparency of information on the current status of preparation (including on the process for developing the Strategic Research and Innovation Agenda). As such, it aims to contribute to further collaboration, synergies and alignment between partnership candidates, as well as more broadly with related R&I stakeholders in the EU, and beyond where relevant.

This informal document does not reflect the final views of the Commission, nor pre-empt the formal decision-making (comitology or legislative procedure) on the establishment of European Partnerships.

In the next steps of preparations, the Commission Services will further assess these proposals against the selection criteria for European Partnerships. The final decision on launching a Partnership will depend on progress in their preparation (incl. compliance with selection criteria) and the formal decisions on European Partnerships (linked with the adoption of Strategic Plan, work programmes, and legislative procedures, depending on the form). Key precondition is the existence of an agreed Strategic Research and Innovation Agenda / Roadmap. The launch of a Partnership is also conditional to partners signing up to final, commonly agreed objectives and committing the resources and investments needed from their side to achieve them.

The remaining issues will be addressed in the context of the development of the Strategic Research and Innovation Agendas/ Roadmaps, and as part of the overall policy (notably in the respective legal frameworks). In particular, it is important that all Partnerships further develop their framework of objectives. All Partnerships need to have a well-developed logical framework with concrete objectives and targets and with a set of Key Performance Indicators to monitor achievement of objectives and the resources that are invested.

Aspects related to implementation, programme design, monitoring and evaluation system will be streamlined and harmonised at a later stage across initiatives to ensure compliance with the implementation criteria, comparability across initiatives and to simplify the overall landscape.

In case you would like to receive further information about this initiative, please contact:

Lead entity (main contact):
UNIFE – The European Rail Industry, Nicolas Furio. nicolas.furio@unife.org
CER aisbl - Community of European Railway and Infrastructure Companies, Enno Wiebe enno.wiebe@cer.be ((with the technical support of UIC)
EIM (European Rail Infrastructure Managers) – Bardo Schettini, bardo.schettini@eimrail.org
UITP – Umberto Guida, umberto.guida@uitp.org
Commission services (main contact):

DG MOVE (Mihaela Williams elenamihaela.williams@ec.europa.eu) and DG R&I

Partnership sector in DG R&I (overall policy approach for European Partnerships and its coherent application across initiatives), E-mail: RTD-EUROPEAN-PARTNERSHIPS@ec.europa.eu

ERRAC started working on a Strategic Research and Innovation Agenda that is expected to be ready by end of September and will be made available publicly on Europa website together with the present document. It should be noted that the "Strategic Research and Innovation Agenda"

[1] https://www.era-learn.eu/documents/final_report_ms_partnerships.pdf

will be further translated in the European Rail R&I Master Plan that will steering the Research and Innovation activities of the Rail European Partenrship.

Executive summary

Rail is a complex system of systems. Like other transport modes, it is an enabler, capable of delivering huge value both to its users and to wider society, with the ability to carry large volumes of passengers and freight safely, speedily, and sustainably. To deliver value to its customers, in terms of mobility and transport services. To do this successfully it must be user-centred, organised, and engineered to deliver the highest levels of dependability, resilience, and service quality. This way it can realise its potential at the core of a competitive and resource-efficient multi-modal European transport network, facilitating a shift from dependence on less sustainable modes. The Green Deal has underlined the urgency of action on decarbonisation: rail is generally vastly more environmentally friendly and energy-efficient than other modes, yet still capable of being even more so. By developing a better understanding of the interfaces and interactions between the components of the whole system and its connections with other modes - creating a functional system architecture - it will be possible to develop an integrated programme of research and innovation. This will be realised by delivery of Transformative Projects, underpinned by a systemic, smart, and sustainable Concept of Operations based on a sector-wide Vision that enables realisation of a Single European Railway Area. The creation of mobility and transport solutions of the Green Deal rely on a rail system capable to serve properly the evolving needs of customers and to meet the urgent needs of decarbonisation answering them together with other modes, delivering societal cohesion, integrating socio-economic developments with a systemic, smart and sustainable concept of operations. A new Rail Research & Innovation (Rail R&I) European Partnership in accordance with Article 187 of the TFEU[2] [3] is essential to coordinate this innovatory work. It will be the strategic pillar to forge an essential element in the transformation of Europe's rail systems into the major component of a sustainable mobility throughout the Union and beyond, focusing and maximising. Only through forward looking cutting edge, integrated and systemic research and innovation, it will be possible to tackle the complexities of rail and maximize the benefits of the R&I investment both within the Union and in global markets.

[2] Hereinafter any reference to "European Partnership", "Rail R&I Partnership", "Rail R&I iEP", or similar definition is intended as body of the European Union established in accordance with Article 187 of the Treaty on the Functioning of the European Union, i.e. an institutionalized European Partnership as referred in the Article 8(1)c of the Proposal for a Regulation of the European Parliament and of the Council establishing Horizon Europe (HE) – the Framework Programme for Research and Innovation (COM/2018/435 final).

[3] For the public consultation purposes, the given name is "Transforming Europe's Rail System". Consideration should be given to keep the acronym "S2R", as also suggested by DG MOVE/European Commission at a S2R GB meeting, or to have a simpler and clearer name, which would identify the overall objective, such as "Rail4Europe JU" or R4E JU.

Contents

1 Context, objectives, expected impacts

1.1 Context and problem definition

❖ The rail sector is impacted by the following mega trends and societal challenges:

- **Climate change and pollution:** Climate change is not simply a longer-term existential threat: it is already having an impact on our environment as well as the everyday life of citizens. It is posing challenges to the resilience of the transport system, particularly infrastructure and rolling stock. The transport sector is responsible for almost one quarter of Europe's greenhouse gas (GHG) emissions. The increased concentrations of GHGs in the atmosphere, in particular CO_2, are responsible for the warmer temperatures, which are disrupting climate patterns. Road vehicles cause more than 70% of these emissions. This contrasts starkly with the green credentials of rail – responsible for a mere 0.5% of emissions in 2016[4]. Additionally, almost all Europeans living in cities are exposed to air pollution levels that exceed the health-based air quality guidelines set by the World Health Organisation (WHO). About 374,000 premature deaths occurred in the EU during 2016 due to emission of fine particulate matter, road transport being one of the principal sources[5]. A modal shift to public transport with rail as a backbone (urban rail in urban areas) is a self-evident priority[6].

- **Urbanization:** Around three out of every four people in the EU live in urban areas (compared to around 50% in 1950). This figure is expected to rise to 80% by 2050. Urban areas account for 85% of Europe's GDP and real estate is often at a premium. Space devoted to road traffic, including space for parking vehicles, accounts for more than half the total area of many cities, while road congestion – estimated to cost about €130 billion annually – has a major negative impact on competitiveness as well on the urban environment. Clean public transport and rail in particular, can make a dramatic contribution to ensuring the sustainability of essential mobility.

- **Ageing population**: Increased life expectancy and falling birth rates mean that the number of elderly people in the EU is projected to be more than 50% greater by 2080 compared to 2016. They will make up almost one third of the total population (compared to less than one fifth today). Meanwhile, the ratio of people at work to the remaining population is expected to fall to 2:1, compared to the present 4:1. Not only are patterns of travel likely to change, the labour market is forecast to be under considerable pressure. These trends, together with the continuing shift from rural areas to urban agglomerations, will create new challenges for transport provision.

- **Transport and behavioural change:** Transport providers will need to adapt to the needs and aspirations of end-users, including behavioural trends such as increased home working and on-line shopping, which may have been accelerated by the experience of the Covid-19 pandemic. Technological innovation is opening the way to seamless intermodality, creating opportunities for greater interoperability with other modes and delivery of smart and bespoke services that can offer connectivity whatever the mode, wherever the place. Mobility providers will need to engender and deploy new skills in reinforcing users'

[4] https://www.eea.europa.eu/themes/transport ures
[5] https://www.eea.europa.eu/publications/air-quality-in-europe-2019
[6] See European Court of Auditors special report of 06/2020: https://eca.europa.eu/en/Pages/DocItem.aspx?did=53246

willingness to embrace a shift towards more sustainable mobility whilst tackling a range of challenges from data management to cybersecurity.

❖ These societal challenges are reflected in specific opportunities for the rail sector:

- Transformation of the transport sector is crucial to achieving Europe's climate policy objectives, particularly if it is to be the world's first climate-neutral continent by 2050: a 90% reduction in transport emissions is required by 2050. Rail can and should play a significant role as 'a game changer' in shifting to sustainable and smart mobility.

- So far, the benefits of rail have not yet been exploited; the share of passenger rail in EU land transport (in passenger km) increased from 7.0% to 7.6% between 2007 and 2016; and, for freight, since the peak in 2011 (19%), the rail share in EU land transport (in ton.km) has decreased to 16.65% in 2017[7].

- The rail industry needs to embark on accelerated innovation if it is to realise these opportunities by transforming itself to become the mode of choice for potential users. It will only succeed in this if it can achieve new levels of dependability, building on digitalisation, automation and the optimisation of asset use, exploiting rail's capacity to shift large volumes of passengers and freight speedily and safely as part of a wider European mobility system, assuring competitive good value to its customers.

❖ The European rail system has long suffered from fragmentation of its component systems. To many outside observers there appeared to be a lack of Union and sector-wide agreement on a common vision for rail and how it could best be delivered operationally. The effects of this fragmentation manifested itself in various ways, including conflicting national visions for the future of rail and an initial reluctance to prioritise development of an interoperable European Railway System, and wariness about the Commission's initial proposals for the Fourth Railway Package. As well as the problems of dovetailing top-down technology initiatives, like ERTMS, with operators' perceptions of their requirements, and the difficulties in gaining market-uptake for piecemeal rail-research funded under previous Framework Programmes; disparate approaches towards integrated mobility, particularly in relation to regulatory frameworks[8]. Fragmentation still characterises much of Europe's railway system with the majority of technical sub-systems and operations reliant on non-interoperable constituents. Lack of standardisation and fragmentation among different national regulatory frameworks, rules and legal guidelines prevents the full deployment of a seamless rail network. Though the Technical Standards for Interoperability now address many issues, there are still difficulties interfacing with legacy systems, with parts of the systems which do not directly affect interoperability and so are not harmonised, and with new innovations risking re-fragmenting the system. S2R's Research & Innovation Programme is designed to bring bottom-up, operational, and technological solutions to the market, paving the way to address the fragmentation among rail ecosystems. This work, as initially designed and implemented, constitutes the first step towards an integrated system approach, which is beyond the capacity of individual stakeholders or sector representatives.

❖ In attempting to tackle the challenges facing the rail sector, the European Commission's 2011 Transport White Paper ("Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system") set out a number of key goals to be achieved by 2050.

---

7 https://ec.europa.eu/transport/sites/transport/files/legislation/com20200078.pdf,

8 The Urban rail segment is excluded from the scope of the Interoperability Directive (and from the relevant TSIs). Urban rail is also today excluded from the Safety Directive, and each country/region may adopt its own solution depending on the local situation. In addition, urban rail systems are operated under public service contracts as part of integrated local public transport systems (of which urban rail lines are the backbone).

These included a 50% shift of medium distance intercity passenger and freight journeys from road to rail and waterborne transport, and the elimination of conventionally fuelled cars from cities. Since the adoption of the 2011 White Paper, significant progress has been made towards the objective of creating a Single European Railway Area with the overarching goal of revitalising the rail sector by completing the single market for interoperable rail services and making European railways more innovative and competitive vis-à-vis other modes of transport[9]. A variety of instruments were deployed. There was a consolidation of the legislative approach with the 4th Railway Package, the establishment of the Shift2Rail Joint Undertaking, an Urban Mobility Package and investment to modernize the rail systems through the Connecting Europe Facility (CEF) funding instrument. For various reasons the specific challenges faced by urban rail were largely left unaddressed by these initiatives, each country or region adopting the solution that best meet local circumstances. Urban rail is excluded from the Interoperability Directive and the Safety Directive, as well as from the Regulation on Rail Passengers' Rights. There is now a compelling case to identify the R&I areas whose results would have positive impact at local level through a joint European effort, in particular in the interaction of urban mobility services with a future comprehensive European Traffic Management, starting from managing European national mainline network. Another example would be working on common specifications at EU level for some sub-systems and components' design, technology transfer between different rail systems, and standard interfaces. The set-up of the next Rail European Partnership Programme will take these considerations into account, avoiding the creation of new barriers whilst favouring synergies that can deliver cost-efficiencies whilst responding to demands for increased mobility and end-to-end services.

❖ As a consequence, of these difficulties, amongst others, today's rail systems:

- Have under-exploited potential to serve more users in Europe and therefore accommodate the anticipated jump in demand arising from modal shift, although the prevalence of 'pinch-points' on the network means that this will require the deployment of innovative technologies.

- Have heritage lifecycle costs which need restructuring to allow for the provision of new integrated and connected services of a defined quality at competitive prices – bringing down CAPEX[10] and OPEX[11], addressing ageing of technology, infrastructure and rolling stock and introducing new skills into an experienced workforce.

- Are designed to deliver widely recognized safe, resilient, reliable, and sustainable mobility but generally have systems that may impede flexible adaptation to the evolving needs of its end-users and new market opportunities

- Are generally regarded as insufficiently integrated with other transport modes, despite significant improvements in some areas, failing to deliver the seamless mobility experience that many end-users seek

- Are not yet widely recognized for the extent to which they have embraced digital opportunities, consequently making a career in the railway sector less attractive to those with the relevant skills.

---

[9] https://ec.europa.eu/transport/modes/rail/packages/2013_en

[10] CAPEX means "capital expenditures", i.e. resources invested to acquire, upgrade, and maintain physical assets such as property, buildings, an industrial plant, technology, or equipment.

[11] OPEX means "operating expenditures", i.e. costs associated with the maintenance and administration of an activity on a day-to-day basis. The total operating cost for an entity may include the cost of goods sold, operating expenses as well as overhead expenses. The operating cost is deducted from revenue to arrive at operating income and is reflected on an entity's income statement.

In this respect, a response to the increase of mobility needs and demand for end-to-end services, requires R&I that, while recognizing the "local" conditions, favouring technology convergence, and, where possible, cost-efficiency.

- The S2R JU was tasked with contributing to the realisation of EU mobility and transport goals through a comprehensive and coordinated approach to research and innovation that would help deliver an integrated, digital and sustainable rail system to help meet evolving end-user needs.

Established only 5 years ago, and operationally autonomous since May 2016, the S2R JU has demonstrated its capacity to manage a series of innovation programmes involving multiple stakeholders in a type of partnership that was new to the sector. The S2R JU secured the support of key rail actors in the form of eight Industry Founding Members, to which were additionally associated 19 Industry Members, eventually obtaining the commitment to a log-term research and innovation approach of almost 70 entities. Such strong coordination at European level led to the involvement of more than 300 other participants in the partnership through "Open Calls", involving railway operators, infrastructure managers, manufacturers, research centres, universities, SMEs, associations and other bodies largely representing the overall panorama of the railway sector. It also managed to attract participants from outside the usual world of rail research, contributing to the further diversification of the research beyond the typical rail research niche.

The mid-term evaluation of the S2R JU in 2017 concluded that the S2R JU has already achieved positive effects by bringing many players to work together towards these common goals, helping to overcome fragmentation in the market and create continuity of research goals. It noted that much of the research being undertaken would not have happened had the JU not existed, and reported wide agreement on its value, concluding that it strongly supported its creation, and the programme of research it had set out.

The commitment and involvement of key players in the rail sector, which the S2R JU has ensured since its creation, provides a strong basis on which to build an institutionalized European Partnership. S2R's work started with the ongoing R&I Projects, was developed through Technological Demonstrators, highlighted in the 2019 Catalogue of Solutions, delivered also via the support to the ERTMS to create a baseline on which to build the new solutions and technologies. As well as, setting the seeds for a new Functional System Architecture[12] facilitating the integration of subsystems to maximize the performance of the railway systems. The System approach will take full account of the needs of the urban rail sector.

In October 2019, the Report of the expert group on competitiveness of the European rail supply industry'[13], commissioned by DG GROW, showed positive feedback by stakeholders on the activities of S2R.

Opportunities and potential:

[12] Defined as the model that should identify system functions, the way they interact and operate. It is through the proper interaction of the functions that the systems deliver and achieve its performance. There might be the need of more structure functional system architecture to depict the proper functioning of complex systems.

[13] https://ec.europa.eu/docsroom/documents/38025/attachments/1/translations/en/renditions/native

The potential for developing and applying new technologies in the rail sector is substantial, as described, for example, in recent position papers published by ERRAC[14]. Future R&I can be expected to deliver significant improvements to almost every element of the rail system in the attractiveness, cost-efficiency and environmental impact of rail services through the application of new technologies and operational concepts. Possible applications identified by ERRAC include the following:

- **New communication technologies** (e.g. 5G) can be used to enable a safe introduction of control, command and communication systems supporting much closer running of trains and greater automation of train operations. Building on the benefits of ERTMS, this would enable a more efficient use of existing networks and potentially reduce the need for costly capacity expansion to accommodate more services. In addition, considering the specific baseline, R&I should look at the evolving needs of urban rail, including technological transfers and synergies expected to be provided by advancements in technology.

- Innovative approaches to building and maintaining infrastructure can improve the resilience of railway networks and reduce both construction and maintenance costs. For example, new materials can prolong the life of key assets, while intelligent monitoring systems can support predictive maintenance and help to avoid costly asset failures. It may even be possible to develop infrastructure capable of self-repairing.

- In the case of **rolling stock**, new materials and structures are needed to reduce cost, weight and track damage, while innovative sub-systems could improve the passenger experience by reducing noise and vibration, allowing smoother braking and acceleration and increasing information on connecting transport services.

- **IT solutions** based on train to trackside or vehicle-to-X connectivity can improve both passenger and freight services. Passengers can benefit from availability of real time data, enabling prediction of their needs, simpler electronic ticketing and provision of information on planned and unplanned disruption. Freight customers could expect to see greater automation of freight handling, enabled through 'situational awareness', and real time tracking, while operators of freight services can benefit from intelligent systems that help to eliminate empty running. At the same time, many improvements can be achieved in all rail networks including at sub-systems and component levels through smart maintenance and IoT-based innovations at European scale or at regional, local or urban level taking into consideration the different markets

- Technologies are being developed that will enable **reduced energy consumption across the whole rail system.** In the case of mainline rolling stock, hybrid propulsion systems allowing energy storage will increase the operational range and flexibility of trains while reducing reliance on diesel fuel. Specific solutions are also being developed for reducing energy consumption of metros and of tram/Light Rail and to operate catenary-free tram/Light Rail. SMART grid technology will allow better management of power supply, improving energy efficiency and reducing environmental impacts.

- For metros, as well as for high-capacity suburban rail systems, saturated or almost saturated lines will require **re-thinking signalling, telecommunications**, etc. R&I into signalling systems adapted to these line types will provide improved solutions and be instrumental in addressing mobility issues for cities.

[14] See for example ERRAC (2018), Rail 2050 vision document, January 2018, and (2016), Research and Innovation – Advancing the European Railway, April 2016, available at: https://errac.org/publications/

- **Rail freight needs to exploit the potential of digitalisation** for increased productivity and to support the synchro-mobility of the logistics network. This is the concept of all modes being integrated in one network, and in which switches between modes are achieved seamlessly, facilitated by an integrated data framework and collaborative data analytics. It underpins a system in which each mode does that for which it is the most efficient. As with passenger rail, this requires breaking down technological, operational, legislative national rail barriers for European agreed solutions that create a cohesive market.

❖ **Challenges of the rail sector and answers:** In its paper 'Rail 2030. Research and Innovation Priorities'[15], ERRAC illustrates both the challenges of the rail sector as well as its responses adapted to each rail segment.

- "*With the mobility landscape changing quickly the 2030 railways sector will answer the evolving needs of end-users/citizens and businesses:* ***attractiveness and convenience*** *need to be provided in real-time, tailored within an end-users/citizens-centric environment through an integrated door-to-door mobility system that provides a punctual, reliable, safe, secure and comfortable service.*

  Maximised ***affordable capacity*** *of the system is key to reducing congestion and providing efficient and economical transport solutions for cities and regions. Part of this can be achieved through optimisation with little or no construction of infrastructure. However, if railways are to become the backbone of customer-centric mobility, bottlenecks in most congested areas will also require new infrastructure. Railways is the only mode of transport that provides the capacity needed in future transport systems, at least with reasonable land use, especially in urban areas.*

- ***Environment sustainability****: With a significant part of emissions coming from mobility, pursuing sustainable mobility is essential. As the railway is the cleanest mode of transport, promoting modal shift towards rail will support the reduction of emissions. But this is not enough, and rail will implement new technical solutions for non-electrified lines and further increase its energy efficiency. Improving the integration of transport systems in populated areas by reducing noise, vibration and carbon emissions will be essential to increase social acceptance in urban environments and beyond. Indeed, rail systems are contributing to mitigating the climate change challenge.*

Addressing these key challenges, the railway has the potential to become the backbone of mobility by 2030. The rail sector will respond to these challenges by promoting and implementing the ***key innovation areas****:*

- ***Digitalisation:*** *A fully connected and integrated digital railway (system, sector and process) will be the basis of efficient asset management. For instance, digital control-command will raise the quality of the operation and support resiliency and capacity, while new end-users/citizens-centric services will raise the system's attractiveness. The digital railway will drive the integration of the overall mobility digital eco-system for all transportation modes. Digital Asset Management will be the base for digital end-to-end mobility for passengers and freight, supported by a resilient and powerful telecommunication network.*

  Automation and Artificial Intelligence: *Automation and AI are key drivers for improving rail and transport as a whole. Real time management of the operation, along with new concepts such as virtual coupling and platooning, will support the increase of flexibility in operations. Autonomous trains and automated freight operation will bring additional predictability and*

[15] Cf. https://errac.org/wp-content/uploads/2019/09/errac_rail_2030_research_and_innovation_priorities.pdf

versatility. All these elements together will support an increase of the capacity and resiliency of the system without major infrastructure investments. It will also lead other rail segments to more end-user/citizen satisfaction from improved traffic management enabling better punctuality and comfort and more flexibility for real-time demand fulfilment.

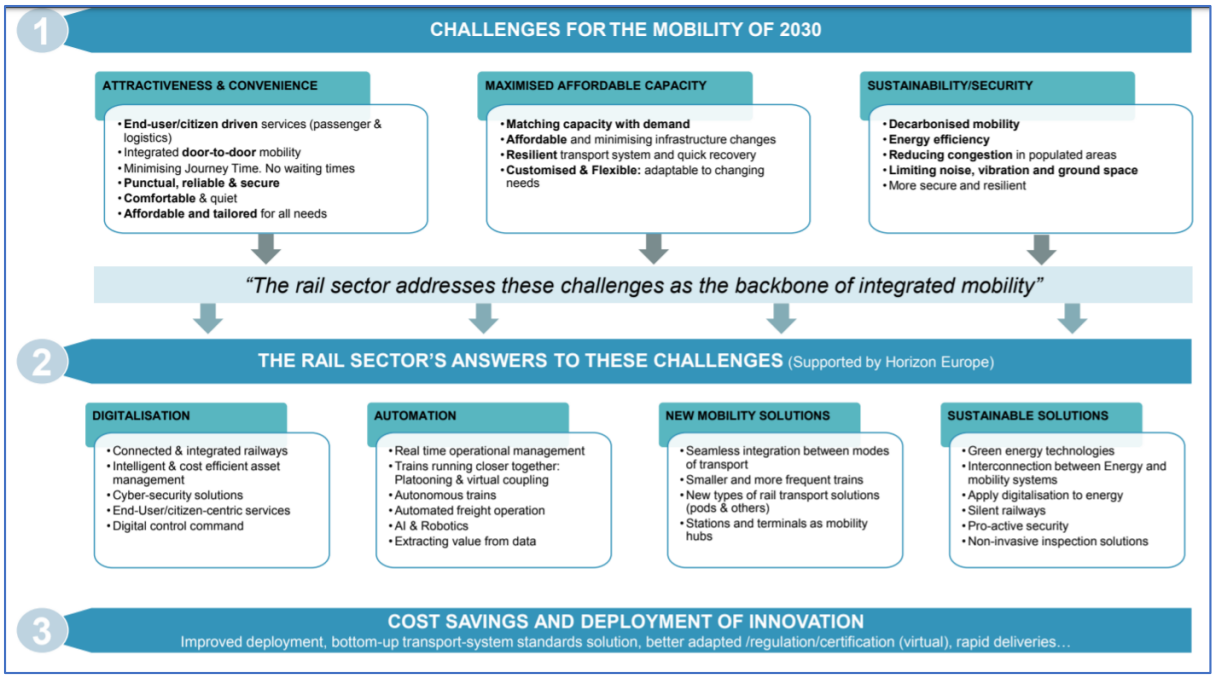
- ***Sustainable solutions:*** *Globally connected energy management systems will definitely be a step towards more sustainable mobility solutions. Holistic energy management systems will allow very efficient use of energy and the minimisation of energy losses. Societal demands will be covered by environmentally friendly solutions (e.g. alternative to diesel, reducing noise, vibration and emissions) and developing pro-active security systems in rail. In addition, green synergies with other transport modes, such as electric road vehicles, will decrease the global transport sector's footprint by improving energy recovery and energy-shared optimisation. Additionally, the initial integration with other transport modes within this shared energy system may open the door to further opportunities beyond the transport sector for the following years (e.g. targeting smart grids by 2040-2050).*

- ***Cost efficiency:*** *Digitalisation of engineering, operations and maintenance activities will reduce the overall cost of the system. For example, the digital twin of railways and virtual authorisation techniques will optimise 'time to market' for railway solutions. Widespread use of the digital twin, with BIM as a prerequisite, will facilitate multi-stakeholder sharing and delivery speed and quality, as well as sustained asset management monitoring on a life cycle basis. The digitalization will benefit from existing and on-going developments related to maintenance activities, such as non-invasive inspection methodologies or predictive maintenance based on big data analysis and the internet of things and other smart devices (e.g. beacons). The digital twin will allow clever and timely interpretation of data into meaningful information, leading to a radical transformation of the business and therefore cost-efficient drivers.*

- ***Fast track to the Market:*** *In the current context it is essential that innovation is quickly deployed and implemented. More efficient bottom-up standardisation mechanisms and simplified regulations will support the implementation of innovations. Standardisation will be defined in a holistic way so to fit into the whole transport sector's needs and in collaboration with other modes, e.g. when tackling digitalisation standards. This includes new thinking for the design of business models.*

- ***New mobility solutions:*** *As digitalisation and automation are developed and deployed, new opportunities for radical changes to the transport system appear, easing its transition from being an asset business to becoming a service business where the end-users/citizens do not own their mobility assets but pick conveniently from a portfolio of services, called "Mobility as a Service", designed around the most sustainable options for each use case or need. These range from the development of railway systems based on shorter but more frequent trains that can couple together virtually, to multimodal shared-mobility solutions with full integration with other modes of transport and even totally new types of transport based on railways, such as personalised pods capable of being transferred to pod-carriers based on rail, road, water and even air. This level of modal integration encouraging shared-mobility and the use of local public transport in urban areas will be matched and facilitated by developments in stations and terminals, which will act as multimodal easily-accessible 'mobility hubs' to meet the full range of user needs.*

The following chart summarizes the challenges and the answers towards 2030 mobility and transport from the ERRAC point of view and provides a useful checklist of the principal challenges that a Rail European Partnership should address:



1.2 Common vision, objectives and expected impacts

❖ **The partnership's contribution to EU policies and priorities of the European Commission 2019 – 2024**

The Political Guidelines issued by European Commission President von der Leyen for the next European Commission contain the policies that the President intends to use to help to deliver on union goals. They focus on six headline ambitions for Europe over the next five years and well beyond:

1. *A European Green Deal*
2. *An economy that works for people*
3. *A Europe fit for the digital age*
4. *Protecting our European way of life*
5. *A stronger Europe in the world*
6. *A new push for European democracy*

The future Rail European Partnership will have both the potential and ambition to contribute directly to the objectives of the European Green Deal. By boosting the rail sector through research & innovation activities and bring together key stakeholders across Europe, the partnership will help the rail sector to fulfil the role of 'game changer'. The European Commission's proposal to make 2021 the European Year of Rail reflects recognition of the railway's role in shifting to sustainable and smart mobility. Moreover, the future partnership will also contribute to additional priorities defined by the Commission for the period 2019 – 2024, particularly: *An economy that works for people, A Europe fit for the digital age, and A stronger Europe in the world.*

Taking into consideration the impact on society of the COVID outbreak and, particularly, on transport and mobility, it became evident that the sector has to include innovative solutions on health & safety aspects into the overall approach to the system design and operation.

Rail infrastructure managers and the railway operating community collectively defined measures to support the restoration of train operations after the period of strict COVID-19 containment measures. There is need to harmonise measures avoiding different sets of hygiene and protection rules for passenger and freight cross border services.

Preventive measures are expected to be gradually reduced over time in line with a reduction of the risk level while in certain cases or areas preventive measures might be temporarily lifted again. Furthermore, as additional reliable mitigating measures become available, these should be considered as alternatives in order to alleviate the burden on passengers and rail workers, whilst maintaining the appropriate level of health safety in accordance with the level of risk. The measures taken should help to build confidence as well as to create a healthy and safe environment for railway workers and customers. At the same time, it is important to enable the infrastructure managers and railway companies to run their operations and systems in a robust and well-functioning way.

Here the rail R&I Programme will have to be sufficiently agile to be able to adapt to the changing environment in the entire mobility chain.

Even if there might be temporary, or even more permanent, shift towards teleworking and consequent reduced demand for daily, peak-time commuting, digital and automated operations will help rail infrastructure managers and rail passenger operators to safely keep delivering both high capacity and high efficiency. This, together with the increased connectivity for the customers on-board is crucial for the accomplishment of the Green Deal ambitions.

The rail freight demonstrated its resilience during the time of the crisis and served the EU economy and society in an unprecedented manner. Without further automation and digitalization, however, it will not be able to compete on the transportation market from the long-term perspective. Here the rail R&I Programme will have to be sufficiently agile to be able to adapt to the changing environment in the entire mobility chain.

European Green Deal [16]

It is clear: "there is no "Green Deal" without rail" as stated by the Chair of UNIFE recently. The railways need to have their potential unleashed. This requires a vision, shared right across the sector, on new Concepts of Operations, structured in a services-focussed system-of-systems architecture, delivered by new technological and operational enablers coming from the digitalization and automation opportunities. This answers the needs of all users, and benefitting from an integrated holistic vision of mobility in which each mode does that for which it is most efficient.

The rail sector is committed to this ambition: firstly, by accompanying the transition towards a lower carbon footprint, with other modes of transport by offering integrated, complementary and connected services (including the so-called "active modes" —— walking and cycling), and secondly, by enhancing the sector's commitment to a circular economy based rail system. Therefore, rail systems must provide climate resilient services for their end-users.

Such an ambitious boost to multimodal transport will result from a combination of policy, legislation and standards and funding, in which research and innovation priorities are closely bound with the realisation of operational priorities and industrial opportunity.

It is around the new Rail European Partnership that the rail sector will lead the transition towards integrated, digital, autonomous, sustainable (decarbonised, life-cycle cost efficient, energy-efficient, etc.) mobility in Europe and towards global competitiveness. It is not about projects delivering piecemeal components; it is about a stable, properly funded, long-term commitment to meet the

[16] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

expectations of the system's end-users – passengers, freight forwarders and public authorities (for whom rail should be a key enabler of broader social, economic and environmental policy objectives).

This will be achieved through an integrated systematic approach, including decarbonisation, automation and digitalization (big data, Artificial Intelligence, distributed ledger technologies, quantum computing and robotics, etc.), sustainability and attractiveness for passengers and freight to connect Europe global transport and mobility hubs with cities, regions, economic centres and beyond. Thus, the European Partnership will embed the priorities of freight and high-speed connections, the suburban and urban view, which the European Commission emphasized in the context of the development of rail, framed around the wider railway operating community's understanding of the needs and aspirations of end-users. This will bring rail systems to achieving "carbon neutrality", with a holistic approach implementing a long-term circular economy view.

In addition, the proposed Rail European Partnership will play a central role with its system of systems approach towards mobility services in establishing constructive cooperation with complementary modes of transportation, mainly with:

- Road transport for passenger and freight taking in account the impact of electro mobility and common grids, automated intermodal hubs, sharing novel functionalities, demand-based approach in last mile transport and long distance transport, high value commodities transports, the urban and rural approach for demand coverage, automated concepts, MaaS, etc.

- Maritime transport, mainly for freight, delivering future operations based on LoD (Logistics on Demand), dynamic logistics, international slots, temperature controlled containers, etc.

- Aviation for passenger transport by rail connected airports and optimal European traffic management systems interactions.

Thus, integrating large scale operational demonstration activities within the new European Partnership will be aligning with the President's vision on "strategy for green financing" and the recent decision of the European Investment Bank to become the first "green" financing multilateral financial institution by 2022.

An economy that works for people: A New Industrial Strategy for Europe

The ambition of these Political Guidelines consists of developing a strong and resilient market economy that supports growth and job creation. An efficient, resilient and reliable railway system, integrated with other transport systems, provides EU citizens with access to a wide range of employment, education and leisure opportunities, as well as contributing to a vibrant market economy that supports growth and job creation.

The European Commission's Communication on 'A New Industrial Strategy for Europe'[17] of 10 March 2020 emphasizes that *"There should also be a special focus on sustainable and smart mobility industries. These have both the responsibility and the potential to drive the twin transitions, support Europe's industrial competitiveness and improve connectivity. This is notably the case for the automotive, aerospace, rail and ship building industries, as well as for alternative fuels and smart and connected mobility."*

[17] https://ec.europa.eu/info/sites/info/files/communication-eu-industrial-strategy-march-2020_en.pdf

The proposed Rail European Partnership will actively seek to further inclusiveness, looking towards research, technologies, solutions, and services that strengthen the European social market economy. Currently, the S2R JU involves in its activities more than 30% of SME beneficiaries in the context of Open Calls' Projects and around 25% in its overall S2R participation. More than 400 entities from all over Europe collaborate within the S2R programme: these will be the base on which to build the new Rail R&I European Partnership. This creates a huge opportunity for businesses of different dimension to work together within an integrated research and innovation Programme, with the opportunity to explore new technologies beyond the short-term product developments, contributing to the creation of synergies delivering added value to the European Union citizens.

It will achieve this by building a strong, focused and balanced membership with carefully conceived opportunities to attract participation by a broad range of the rail system's stakeholders, in combination with possible new partners.

In developing new technologies, solutions, and services, enabled in particular by digitalization and automation, the proposed Rail European Partnership will provide a framework for the rail and non-rail workforce to be involved in the different activities to reconcile the social and market dimension. As the rail workforce is rapidly ageing (the average age of operators' workers being over 50), it will be essential to take advantage of the immense available rail expertise to ensure continuity of activities. In that area the participation of universities and the academic community becomes indispensable, being not only the place to educate future high specialized workers of the sector but also the place where research in many different disciplines coexists naturally, providing an environment to come up with the longer term and disruptive solutions.

This will be achieved, as a priority, ensuring in all occasions equal opportunities, encouraging a diversified workforce, rejuvenating the sector and attracting talented and innovative individuals.

A Europe fit for the digital age: Shaping Europe's Digital Future

In its communication 'Shaping Europe's digital future'[18] of 19 February 2020, the European Commission defines the priorities for Europe to pursue its own way towards a digital transformation. The focus is on three objectives: a Technology that works for people, a fair and competitive economy, and an open, democratic and sustainable society. Digitalisation is considered to be key in reaching the ambitions of the European Green Deal, and transport "*can benefit immensely from digital solutions in pursuing the ambitious sustainability objectives of the European Green Deal."*

The new European Partnership will function as a European platform to deliver an integrated, digital and sustainable European Rail System for the "digital age". The Political Guidelines refer to "*grasping the opportunities from the digital age within safe and ethical boundaries*".

Rail is an integrated, complex, assembly of components that, at given and non-negotiable levels of safety, can maximize their performance (cost-efficiency, punctuality, capacity, etc.) once managed within a system of systems approach during its full life cycle. This will be delivered defining the boundaries in terms of HMI (Human-Machine Interface), cyber-security, resilience, and training.

Rail in the proposed European Partnership aims to draw heavily on the digital advances brought forward by other EU Programmes, such as DEP (Digital Europe Programme). It will be an opportunity to move such advances from theoretical science to concrete opportunities to create market solutions, combining advanced innovation with the need to operate reliable, resilient, safe, and secure systems.

In view of sustainable and smart mobility, the opportunities linked to connected and automated mobility should be explored, with a strong focus on digital innovation, in order to ensure the continued modernisation of key transport system such as rail.

[18] https://ec.europa.eu/info/sites/info/files/communication-shaping-europes-digital-future-feb2020_en_4.pdf

A stronger Europe in the world

The rail sector is an important contributor to industrial growth, jobs and innovation in the EU, with the overall railway sector accounting for more than 1 million direct and 1.2 million indirect jobs in the EU. However, new market entrants are challenging the world leadership of the European rail supply industry, especially from Asia, which offer attractive products at low acquisition costs.

In order for Europe to maintain is leadership, research and innovation effort is crucial: *The world leadership of the European rail supply industry is largely due to its R&D&I capacities. While international competition constitutes a cause for concern for the European rail suppliers, staying at the forefront of research and innovation will be a key factor to ensure that the European RSI preserves its leadership and remains able to compete successfully against foreign suppliers.*[19] To achieve this, in the new Rail R&I European Partnership the so-called triple helix approach, i.e. a close cooperation between academia, industry and governments, will be applied.

The contribution of rail to the EU's economy, industry and society is also highlighted in the Commission's proposal on declaring 2021 the European Year of Rail. Moreover, the proposal emphasizes the importance of rail for the relations between the EU and third countries, in particular in the Western Balkans.[20]

❖ Common Vision and Ambition of the new Rail European Partnership

The new Rail European Partnership is intended to meet these EU policies with an ambitious integrated systemic R&I Programme matched to the needs of the sector and its understanding of those of its end-users.

Rail is a complex system of systems. If the full potential of rail is to be unleashed in realising the European Green Deal and the Commission's associated priorities, the significant improvements envisaged by the new Rail European Partnership require collective commitment to a Common Vision, right across the sector. It will be the product of a structured process undertaken and agreed upon by railway sector stakeholders, coordinated by the Rail European Partnership, and prepared in such a way as to inform its planning and subsequent work. It must be rooted in the wider railway operating community's understanding of the needs and aspirations of its end-users – passengers, freight-forwarders, and public authorities (for whom rail can be an enabler of their broader policy objectives). It will reflect users' concerns about value, performance and reliability and the dependable availability of services at times and places to meet demand. It will reflect an awareness of the need to improve productivity whilst facilitating synchro-mobility of the logistics network and seamless end-to-end mobility, underpinning a system in which each mode does that for which it is the most efficient.

The Common Vision will inform a Concept of Operations. This can then be drawn on as the basis for development of a service-oriented Reference Functional System Architecture (specifying interdependencies, modular approach, open interfaces, standards application, etc.). This fundamental work must be inclusive, its governance and decision processes sufficiently flexible to allow for the required speed and transparency, whilst broad and inclusive to ensure input from the larger community of railways and suppliers, integrating the Scientific Community. The aim of such an approach is the that the Rail European Partnership acts as the single coordinating body to bring the whole sector together, consolidating and coordinating current initiatives, and implementing an ambitious programme of R&I activities.

[19] Final Report: Study on the competitiveness of the Rail Supply Industry (6/11/2019) https://ec.europa.eu/docsroom/documents/38025/attachments/1/translations/en/renditions/native

[20] https://ec.europa.eu/transport/sites/transport/files/legislation/com20200078.pdf

The proposed Rail European Partnership will deliver technological and operational solutions that respond to a new Concept of Operations for Rail, through a System of Systems service-oriented approach, in which an integrated rail system, including freight, urban, suburban, regional and mainline, will realise its full potential. This is done while respecting at the same time the specific needs and operational requirements of those representing different elements of the whole. The work will be carried out in a coherent and suitably transparent and inclusive manner and, where appropriate, coordinated with other transport modes and connected services. The steering of the European Commission and the coordination with ERA essential.

A shared and guiding Reference Functional System Architecture includes all structural rail subsystems and their functionalities (i.e. control command and signalling, rolling stock, energy, infrastructure, etc.) and identifies the necessary interfaces and interdependencies to ensure the System maximize its performance. This Reference Functional System Architecture will need to be adaptable to deal with the interfaces with other modes of transport, such as urban multimodal integrated mobility system with their specific concepts of operation.

This service-oriented new Rail integrated system of systems will interact with other modes thanks to its Reference Functional System Architecture with open standard interfaces for data, enabling interoperable multimodal services. Function can be implemented by rail sub-systems or by other mobility solutions (services and systems) on a case-by-case basis. For example, at urban level, the rail functional system architecture has to be considered in the frame of the whole urban mobility. It is therefore important that interactions and interfaces between rail and other mobility systems and services are identified and characterised, in order to fulfil at best the needs of all categories of users in all rail segments.

There will be potential to establish links and collaboration with other Horizon Europe partnerships, (safe and automated road transport, HPC computing, air traffic management and aviation, ECSEL components and electronic systems, Fuel Cell Hydrogen, etc.), other parts of the Horizon Europe Programme (batteries, steel, space, etc.), European Regional Development Fund, CEF, other Commission services, etc. This will also require addressing data ownership and data sharing to exploit the full potential of Big Data and IoT. Full compliance with GDPR guidelines is also paramount. In principle, the relevant priorities and mechanisms for collaboration will be further assessed, developed and far as possible agreed during the preparation process establishing the partnership, although such approach shall be present all along the life of the programming period.

This specifically means that the proposed Rail R&I European Partnership, within Pillar 2 of HE Programme, will define a strategic research agenda that will materialize also in initiatives requiring the key contribution of other Programmes and it will depend on the input and efforts of such Programmes. But it will also be the responsibility of the Commission Services to facilitate and connect such initiatives, especially when collaborating with different forms of partnerships, especially those non-institutionalized or private consortia.

In terms of synergies with National and International Programmes, the new Rail European Partnership will be able to benefit of the experience acquired in the current S2R JU and its MoUs, which pave the way for reaching regions and towns to create a cohesive mobility and transport. This will ensure connectivity with the ERDF and the Cohesion Fund but also with External Action funds in relation to Africa, for example. The collaboration with other partnerships will depend on the scope and modalities agreed in the context of strategic research agendas. During implementation, it is important to ensure speedy sharing of results between relevant partnerships.

The new Rail European Partnership will be target-driven towards the big challenges within rail and overall mobility and transport. This includes a strong focus on speeding deployment of innovation and market uptake to realise the economic, societal and ecological systemic transitions that Europe need, building on the innovations already delivered by the Shift2Rail JU and other initiatives; cross-sectorial collaborations will be fostered from a mutual-benefit perspective.

In line with the ERRAC Vision, the new Rail European Partnership will encompass urban rail as a core of urban mobility. In 2030, urban rail and urban nodes will be at the heart of the integrated urban mobility systems. This is the only solution to meet societal needs to move large numbers of people in and around urban and suburban areas reliably and efficiently with minimum negative externalities such as pollution, congestion, climate change and use of scarce space.

Around the clock shared mobility will be state-of-the-art and rail stations will become key urban hubs of the smart cities with vibrant living, working and leisure opportunities ensuring social inclusiveness and accessibility. For this purpose, the involvement of the users in all phases of service implementation is key for delivering services based on their various travel needs.

The expected impacts of the proposed Rail European Partnership are notably:

- A new harmonised Concept of Operations for Rail, through a System of Systems service-oriented approach;

- A coherent, integrated rail system delivering resilient, reliable, sustainable 24/7 available services with provision for open access as well as "public service" contracts in urban nodes, for example, for urban rail within integrated mobility;

- Fast delivery of R&I results to the market through coordinating live, large-scale demonstrators at Union level, combining regional, national and European Programmes;

- Sustainable integrated mobility via new concepts of rail operations and services across Europe (high speed, regional and urban context) to the benefit of the EU citizens;

- The new ability with increased capacity required to "shift onto rail" … "a substantial part of the 75% of inland freight carried today by road". This together with the measures to manage better, and to increase the capacity of railways which the Commission will propose by 2021;

- Improved operational and planning process by decision support developed as demonstrators and simulators connecting actors and promoting sharing data and develop the railway system together and to solve identified problems;

- Significantly increased competitiveness of the EU Rail Supply Industry worldwide;

- Quantum leap progress in the knowledge base and innovation capability of the sector for the years to come. This means transforming the sector from a legacy knowledge based on a trial and error approach, into a scientific and digitally driven application of all functions. This will allow (e.g. with the use of AI and digital twin simulations, among others) a progress in the rail system and its sub-components optimisation for improved and new services customised for final user needs.;

- European universities that remain world leading in research and education in the railway area.

- New opportunities and more attractive skills ecosystem for the skilled rail workforce and a challenging environment to attract new generations of engineers;

- Availability of urban rail on most densely used corridors with priority over other forms of motorised mobility. Most trains run fully automated or with the highest level of automation and safety. Improved quality of service, robustness and reliability through the integration of new tested and hardened technologies, i.e. full exploitation of digitalisation for operation,

maintenance and commercial processes. Urban rail sector has demonstrated its ability for quick up-take of any innovation proposed within and beyond the sector.

These impacts will be mainly driven by monitoring, using key performance indicators, along with the following targets:

- Flexibility: rail systems capable to respond promptly to the users' needs, capable of learning from the users' behaviours and adapting to them (demand-driven approach), building upon a new model for data management while complying with GDPR;

- Sustainable integrated traffic management system(s) for European interoperable operations, door-to-door, seamless and integrated mobility paradigm and attracting citizens to the public transport system: towards zero capacity waste, 100% reliability and 100% flexibility;

- Competitiveness of rail freight in Europe by introducing innovative and new operational solutions within a multimodal environment;

- Life cycle cost reductions;

- Increasing resilience, reliability, availability, maintainability: towards zero failures and 100% asset availability also under severe climate conditions;

- Supporting the reduction of emissions, reduction of noise, towards zero energy waste, zero carbon footprint and 100% clean energy;

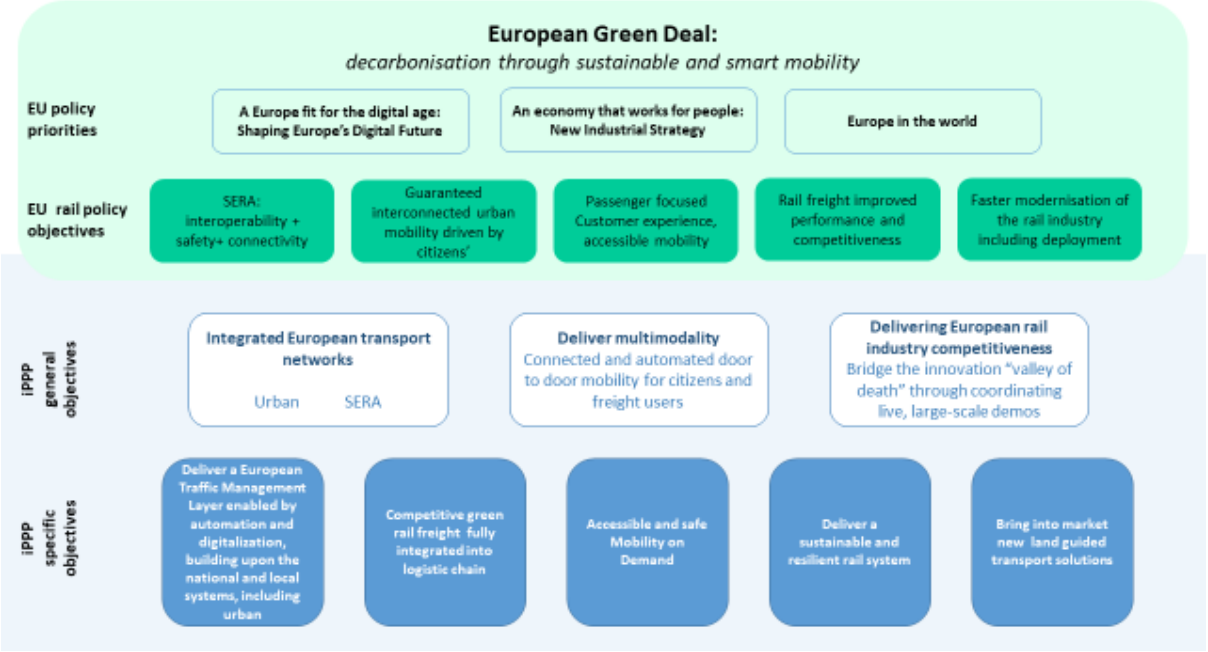
- European and international standards, EU-wide commonly agreed harmonised specifications and European regulations, especially when necessary for interoperability within the SERA and for a standardised modular Reference Functional System Architecture framework which allows for easy inclusion of R&I results;

- Significantly increasing the competitiveness of the EU Rail Supply Industry through industrial European solutions, which will foster the leadership within and outside Europe, including to the benefit of the whole industrial sector.

The European Rail System of 2030 will make wider societal, economic and environmental contributions. It will produce significant value to the wider economy thanks to a variety of innovative technical and operational solutions that will be delivered by joint research and innovation activities, and will in parallel help to reduce negative externalities (directly and indirectly) and it will contribute to an overall sustainable growth and jobs creation.

In addition, the setting up of a European Partnership (notably the institutionalised form) would allow contribution to policy making, regulatory framework and standards' development, which will pave the way for the Member States'/Regions/Urban's investment in new railway systems.

The following diagram depicts both general and specific objectives of the partnership and puts them into context with the EU rail transport policy goals, as well as with the Union's overarching political priorities.



❖ **General objectives**

The proposed Rail R&I European Partnership will contribute to delivering the Green Deal in line with the Commission's views on delivering it through research, innovation and a renewed industrial policy.

❖ The challenges identified in the Horizon Europe cluster "Climate, energy and mobility" targets to fight climate change, improve the competitiveness of the energy and transport industry as well as the quality of the services that these sectors bring to society. The overarching drivers are the need to decarbonise the energy and transport sectors by 2050, while, at the same time, boosting their competitiveness – taking into account that both sectors represent an important share of GDP and jobs in Europe.

❖ Infrastructure, network development, digitalisation and workforce skill development are key enablers to achieve carbon neutral economy, as well as to enhance security (including cybersecurity), safety, resilience, reliability and efficiency of the energy and transport systems. In addition, climate resilient systems help the EU with climate change adaptation and the related socio-economic transition.

❖ The Orientations towards the first strategic plan focuses on targeted impacts across the various parts of the cluster. These include:

- Achieving an advanced knowledge base in climate science that can guide the development of required policy measures and low-and zero-carbon technologies essential to catalyse the transition to a climate-neutral emissions economy and society;

- New cross-sectoral energy/transport solutions enabling both the clean energy transition and the decarbonisation of transport;

- New, affordable, smart, inclusive and sustainable mobility services that will result in significant safety, environmental, economic and social benefits such as reduced accidents, decreased congestion, reduced energy consumption and emissions of vehicles, increased efficiency and productivity of transport operations, improved working conditions and the creation of new jobs.

- ❖ "Creating a toxic-free environment requires more action to prevent pollution from being generated as well as measures to clean and remedy it". "Multimodal transport needs a strong boost" and this will require increasing the capacity of railways to take on board a challenge of such magnitude. As indicated, a) delivering integrated pan-European Rail Networks, b) delivering multimodality and c) delivering European industry competitiveness for the whole sector will make rail the backbone of the mobility and transport transition towards carbon neutral economy.

- ❖ The new Rail European Partnership will in particular address this research, innovation and development priority while contributing to the overall research objectives defined for the 'Climate, energy and mobility' cluster.

The European Partnership will therefore, be able to play a significant role in the rail sector's contribution to achieve the objective of 'sustainable, safe and affordable' transport, as it has been included for the future priority for EU transport policy[21].

This is reflected in the following **EU transport policy priorities**, which are embedded in the activities of the partnership[22]:

- Creation of a Single European Railway Area to achieve a more sustainable, safe and interoperable Union connected transport system;

- Guaranteed interconnected urban mobility driven by citizens' needs with urban rail as a backbone;

- Improved customer experience and accessible mobility ensuring high quality, attractive, competitive and affordable rail services are offered;

- Improved rail freight performance in order to increase its competitiveness;

- Faster modernization of the rail industry by fostering innovation and digitalization and deploying new solutions with higher pace, including for the overall benefit of the whole rail sector.

- ❖ **Specific objectives of the partnership to be achieved by 2030**

These Union policy objectives are embedded in the conceptual framework for the research and innovation activities to be carried out by the new Rail European Partnership with their industrialisation and investment plans. Aligning to these priorities, the following general objectives have been defined for the new partnership:

- **Delivering Integrated European Rail Networks that respect the specificities of the various rail market segments**

Rail is a complex system committed to deliver value to its customers: a one shared sector vision towards improved operational reliability, resilience and efficiency, capacity to adapt to changing trends and secure the sustainability of business models for the European passengers and the freight logistic value chain will drive the proposed Rail R&I European Partnership.

[21] Cf. Mission letter of the President-elect of the European Commission to the Commissioner-designate for Transport of 7 November 2019.

[22] Answers to the European Parliament – Questionnaire to the Commissioner-Designate Adina Valean

The new Rail European Partnership will contribute to deliver the Single European Railway Area bringing to the market **an end-user oriented, integrated, sustainable and digital rail system of systems, for the high-speed network, freight and commuter lines, integrating regional lines for the robustness and resilience of corridors operations.**

Building upon a solid Reference Functional System Architecture shared by the sector – whose mainline part is currently under development within the S2R JU together with the sector under the EC "CCS system framework"[23] and in coordination with the European Union Agency for Railways (ERA) – the proposed Rail European Partnership will perform research and innovation activities that will deliver an Integrated European Railway Network. This will be achieved by eliminating barriers to interoperability and providing solutions for full integration, where necessary, covering traffic management, vehicles, infrastructure and services.

Some aspects of the current fragmentation problem, for example, the separation of sub-systems provided by different industry organisations as well as differences in standards and operating practices, may be removed over time. This can be done through the application of innovative system solutions (mostly combining heterogeneous data, modularity, and a Conceptual Data Model enabling an alignment of all ongoing modelling initiatives in terms of principles and digital data exchange) into a common Reference Functional System Architecture that capitalizes on the work of S2R and exploit standardisation and modularity opportunities. This European integration through a common understanding of the global performance of the mainline rail system and common application of operations across EU countries is the necessary step to ensure the achievement of SERA. Additionally, it will facilitate the identification and definition of common functional open interfaces towards other transport modes and systems, opening the door to new business opportunities and contributing to keeping the European supply industry at the forefront of worldwide competence. Finally, managing an integrated interoperable rail system, able to find its optimum in Europe, will ensure that services provided by the rail sector best answer the user and citizen needs, bringing closer together cities, regions and countries.

Urban rail mobility priorities will have to be addressed properly providing opportunity for urban rail stakeholders' categories to contribute to the definition of European R&I priorities and solutions capable to address local issues and urban different scenarios.

The major changes will be provided through connecting fundamental science with applied research, up to live large-scale demonstrators to ensure that the system transformation of mobility, where railway would play the backbone role, is driven by a combination of policy, including market, objectives and a continuous effort to ensure new scientific and technological discoveries are embedded in the programme.

- **Delivering multimodality**

As already indicated, the European Rail Integrated System of Systems will interact with other transport modes. In particular, smart cities and urban nodes should build upon urban rail and a variety of existing and new shared mobility services to address the societal changes and the different expectations and needs of expected passengers. Integration between passengers' hubs – airports, train stations, ports - as part of urban nodes with urban mobility, building upon the strengths of urban rail should be delivered. In the same manner, rail freight has to be looked at in the context of integrated logistics, connecting with ports and other freight hubs.

[23] CCRCC 2019, DG Move presentation

To deliver upon the Green Deal ambition on an automated and connected multimodal mobility, the proposed Rail European Partnership will deliver "door-to-door mobility" and "on-demand door-to-door mobility" through the introduction of digital technologies and operational solutions. These would aim to maximize the performance of urban rail transport (metro, light trains, trams), seeking synergies, and where needed and proven to be cost-efficient, integration with rail mainlines services and other transport systems. Stations will have to be part of this ecosystem and evolve to self-sustainable centre to serve new smart cities concepts.

The involvement of additional investors and stakeholders, including the European platforms (e.g. ERRAC, ALICE, ERTRAC, ACARE, Waterborne) and other European and national programmes, as well as working directly with other transport sectors, are necessary.

- **Delivering European rail industry competitiveness for the whole sector**

The "Report of the expert group on competitiveness of the European rail supply industry – October 2019" concluded that the "*World leadership of the European rail supply industry is largely due to its R&D&I capacity. While international competition constitutes a cause for concern for the European rail suppliers, staying at the forefront of research and innovation will be a key factor to ensure that the European RSI preserves its leadership and remains able to compete successfully against foreign suppliers*".

The new Rail European Partnership will perform research and innovation recognized for its excellence in tackling socio-economic challenges and its ability "*to demonstrate their impact in real life conditions,*" and "*the support to large-scale deployment innovations is instrumental to market uptake.*"

Moreover, these general objectives respond to the needs and challenges of the sector, as outlined in section 2.1, while building upon the results delivered under the current European Rail R&I Programme.

❖ **Operational objectives of the partnership**

The specific objectives have been further refined by setting, in a first version, operational objectives for the new Rail R&I European Partnership. These correspond to several key areas of research in which clusters of projects can be grouped and which will require further refinement during the overall process of the preparation of the proposed European Partnership and its Programme. They will take account of work carried out in connection with the preparation of, and outputs from, the Common Vision, the Concept of Operations, and the Reference Functional System Architecture.

The operational objectives of the partnership are the following, to be applied appropriately to all segments (high-speed, urban, regional and freight railways):

- Alongside the development of the overall Functional System Architecture, the development of associated harmonised specifications and standards

- Design, establish and initiate the operations of a European Railway Traffic Management Layer (ETML) and European Rail Network Manager: develop the operation management layer intended to optimise train movements (operations) at EU level, building upon the national and local systems to operationalize, inter alia, the Market Pillar of the 4th Railway Package.

- Design and establish a new generation of traffic management solutions serving optimised integrated mobility at local level, with urban rail at the core;

- Competitive green rail freight fully integrated into the logistic value chain: through data integration, digitalisation of processes and common technological solutions applied to live pilot operations across EU to serve user needs considering efficient, on time delivery;

- Accessible and safe Mobility on Demand: through zero barriers, physical and digital, rail system for passengers:

    - Mobility solutions for customers and citizens: deliver a demand driven seamless, affordable and integrated system with multimodal door-to-door solutions combining long and medium distance travel with integrated local public transport services and mass transit networks in a holistic approach of mobility and, for mainline, also moving away from a supply-driven mobility system with fixed and separate timetables per mode;

    - High quality and safe (health) service barrier-free, including clear solutions for addressing PRM's inclusiveness and rural/low demand area's needs, as well as with non-railway solutions; flow management, including addressing health and overall safety issues, to ensure public and mass transportation systems through the use of a combination of digital and physical solutions;

- Deliver a sustainable and resilient rail system: by developing zero-emission, silent railway system and climate resilient infrastructure, applying circular economy to the rail sector, piloting use of innovative processes/technologies/designs/materials in the full life-cycle of rail systems;

- Bring into market new land guided transport solutions: through concepts such as "pods", "moving infrastructure", "hyper-speed systems" and other disruptive ideas;

- Ensure, through cutting-edge Rail R&I, the European leadership of the sector around the globe.

The timeframe for such major R&I objectives achievement is estimated on the next 10 years, from 2021 to 2030 (duration of Horizon Europe and beyond).

❖ **Collaboration opportunities**

The proposed Rail partnership Programme will, on the one hand, take stock of the progress achieved by different technologies, starting with building upon the S2R JU, research and other sectors and bring the relevant solutions to the rail systems and, on the other hand, explore new fields to contribute to the overall transformation of transport and mobility. Collaboration with relevant stakeholders and interested actors (including end users and staff) at European, national, regional and sectorial level will be essential in all phases.

- From a technological-angle, the new Rail European Partnership should connect with the EU partnerships for clean hydrogen (new energy concepts), Key Digital Technologies (including ECSEL, block chain, transversal to the entire Programme), and High Performance Computing (transversal to the entire Programme). As well as, air traffic management (multimodal integrated approach, traffic and network management), aeronautics (new material, alternative fuels, etc.), and 5G PPP (transversal to the entire Programme). In addition, and subject to their evolution, opportunities for collaboration may come from the PP on cyber-

security, batteries as well as on the connected vehicle (sharing urban space with urban rail, level crossings, network concepts, etc.). It may also connect with other European Partnerships that might be established under Horizon Europe, provided that they would share their strategic agendas beyond the private interest of their stakeholders.

- Synergies with KICs under the EIT will be explored, in particular Energy, Mobility, Climate and future ones.

- These links/future collaborations will have to be better clarified also during the development of the strategic R&I agenda and further defined in setting-up the the multi-annual work programme. Regular contact will also be maintained during the life of the partnerships to assess opportunities for cooperation. A good example to follow is the excellent liaison work implemented between Shift2Rail JU and the on-going Fuel Cells and Hydrogen partnership within Horizon 2020 or national/regional programmes.

- The European Partnership should increase the cooperation with the European Technology Platforms / Partnerships that already have contact with the railway sector, though the entities working in their respective fields, and perceive this interaction as an added value. The railway sector should strengthen the cooperation with them to identify further synergies and align roadmaps (ERTRAC, TP Waterborne, ECTP, ACARE, ALICE).

- Synergies and cooperation with the Horizon Europe European Innovation Council (EIC) will be established to ensure the involvement of start-ups in the Rail European Partnership; it will be important that the EIC will connect start-ups with the new Rail Partnership to ensure no overlaps and uncoordinated funding.

- Synergies and cooperation with the Horizon Europe Missions will be established, in particular, the one on Climate Change and the other on Smart Cities; this will also be linked to the new role of VP Timmermans with regard to the Green Deal. The technological and operational results of the new Rail R&I European Partnership can be key enablers to deliver those mission objectives, as well as missions can help shaping the future R&I.

- Synergies and cooperation with the Knowledge and Innovation Communities (KIC) will be established (e.g. with the urban mobility, energy, and climate KICs) to increase demonstrations and facilitate deployment of technologies. Initial contacts have been established under the current S2R Programme and it will require further developments. The work in terms of Energy KIC on Batteries can for example accelerate the hybridisation of rail traction systems; similarly, with the funding for hyperloop systems.

- At European level, collaboration/integration with TEN-T related activities and with the Rail Freight Corridors would be instrumental for the achievement of the EU policy ambitions. As the Rail European Partnership will conduct large scale demonstration activities, the natural next step would be the deployment of successful results in strategic European corridors and the implication of the Rail European Partnership is necessary to ensure the system (of systems) coordination of timely deployments of EU added value solutions through CEF and possibly other instruments.

- At National and Regional level, cooperation will be paramount, on the one hand, to ensure the alignment of rail programmes and avoid duplications and, on the other hand, to accelerate the market uptake of the technological and operational solutions for faster and bigger impact.

- There is a crucial need of a cooperation with local authorities and local operators to define and agree, in answering common shared priorities for urban mobility, on EU-wide commonly agreed harmonized specifications for urban rail and other public transport services.

- Seeking opportunities to maximize the leverage effect of the proposed European Partnerships' impact, including through the EIB and other multilateral financial institutions.

Additionally, improving the European Rail System, investigating new operations, services and their connection with other transport modes will decrease the overall transport climate impact and create new business/collaboration opportunities across sectors.

The new Rail R&I European Partnership will leave room for unanticipated emerging and break-through technologies with a high potential for delivering operational solutions to HE objectives focusing on decarbonisation, addressing mission oriented societal challenges, strengthening the international collaboration with relevant rail partners. Dissemination and communication activities will be critical in ensuring the inclusiveness of the Programme.

❖ **Estimation of how much R&I investments are overall necessary to achieve the specific objectives**

As a baseline for reference, the current S2R JU runs a R&I Programme of a value of EUR 920 million delivered largely by the key partners comprising and serving the sector (suppliers, operators, infrastructure managers, research community, including from outside rail). This also includes drawing on their own financial resources (paying salaries, investments, assets, technologies, etc.), complemented by EUR 450 million Union funding. This results in a net contribution of the rail industry of EUR 470 million. The current S2R Members' funding is at 44.44% of their overall Total Project Cost for the indirect actions they performed, corresponding to around 33% of direct costs plus the usual 25% flat rate provision for indirect costs. The leverage effect based on direct costs is EUR 1 funding creating 3 EUR of R&I activities.

As shown by its mid-term evaluation, S2R effectiveness would benefit from a wider representativeness of infrastructure managers and railway undertakings, including urban rail actors. At the same time, the need for major involvement of the rail community, and beyond, to explore new opportunities, as well as to accelerate market uptake were highlighted. Finally, the integration within the next programme of entities from under-represented Member States was a point of attention.

This requires the necessary funding to match the ambition of the European Union among others with the targets of the Green Deal and vision presented here above as well as the points of attention of the mid-term evaluation.

In this respect, the sector considers that a Programme estimated at the total value of EUR 3.3 billion (inclusive of in-kind contributions for additional activities) matched by a funding of EUR 1.5 billion, at least, would allow achieving the following. This should not be looked as separated chapters, but as integrated elements of the R&I life cycle structured around two R&I Pillars with specific dedicated representativeness:

The System Pillar

- Concept of Operations for Rail, through a System of Systems service-oriented approach, providing the overall framework for delivery of R&I, taking into account interfaces within different rail segments and other modes. These activities should ensure a common approach and efficient use of resources; the proposed rail European Partnership will be the platform for and provide the coordination and resources to enable sector convergence on common

solutions at European level. The rail European Partnership shall therefore in particular coordinate and consolidate all relevant sector initiatives, noting the importance of unified requirements from the Railways. This is complementing and underpinning the focus on research and innovation towards impact-oriented solutions. Indeed, the work to define and then maintain the operational concept and functional system architecture will be the framework within which the R&I work progresses with logical interactions.

- The new rail European Partnership will be the "coordinating body" for the sector, comprising the railway operating community (infrastructure managers and railway undertakings), the rail supply industry and other concerned actors (e.g. wagon keepers etc.), to propose the operational concept, the functional system architecture, with a wide, shared support, which can, after validation, result in the proposal for the associated specifications and standards. Such role will be defined in a dedicated System Pillar with a specific role for the Commission, together with ERA, the sector and the Executive Director of the JU. It is preliminary to assess the value of the activities to be performed, the level of investment per year that is not expected to be linearly distributed along the life of the new European Partnership, the funding models; nevertheless, based on the experience of other sectors an indicative amount within EUR 0.1 billion (funding) could be indicated.

The Innovation Pillar

The R&I activities to deliver the Concept of Operations, addressing the specific segments' interfaces, will be structured with this Pillar and established around the following:

- Exploratory and fundamental research – this will allow integrating the research community, innovators/start-ups and other institutions to work together with the rail sector to explore and generate new ideas, including breakthrough solutions for an agile market implementation or for long term deployment. It is essential to create a pipeline of innovative ideas that will allow the rail systems to evolve over time to maximize its performance for citizens and business.

Based on the current demand from the so-called S2R Open Calls and on the increased objectives, it can be expected that allocating an estimated funding within EUR 0.2 billion to these activities would allow creating a major leverage effect to the scientific community and start-ups.

This will help to create a new generation of researchers, engineers, Digital and rail specialists to cope with the expected ageing of the rail workforce/expertise in the next decades. It should also be seen as a complement to the EU blueprint for rail sector on skills, expected to start in 2021.

It should be underlined that the actors who will mostly benefit from this category of research activities (e.g. academics, university etc.) will certainly also take part in applied research, having strong expertise and capacity to work towards higher TRL together with the industry at large.

- Applied Research and innovation, including relevant development, will be the core of the research and innovation activities where desired market solutions, containing most of the technological and operational solutions, will be pushed to move towards market deployment or terminated because not progressing as expected.

The proposed Rail European Partnership will focus on key priorities but addressing the subsystems of the various rail market segments and, where relevant and cost-effective, standardisation or commonly agreed harmonised specifications needed to deliver them. Automation will require converging on

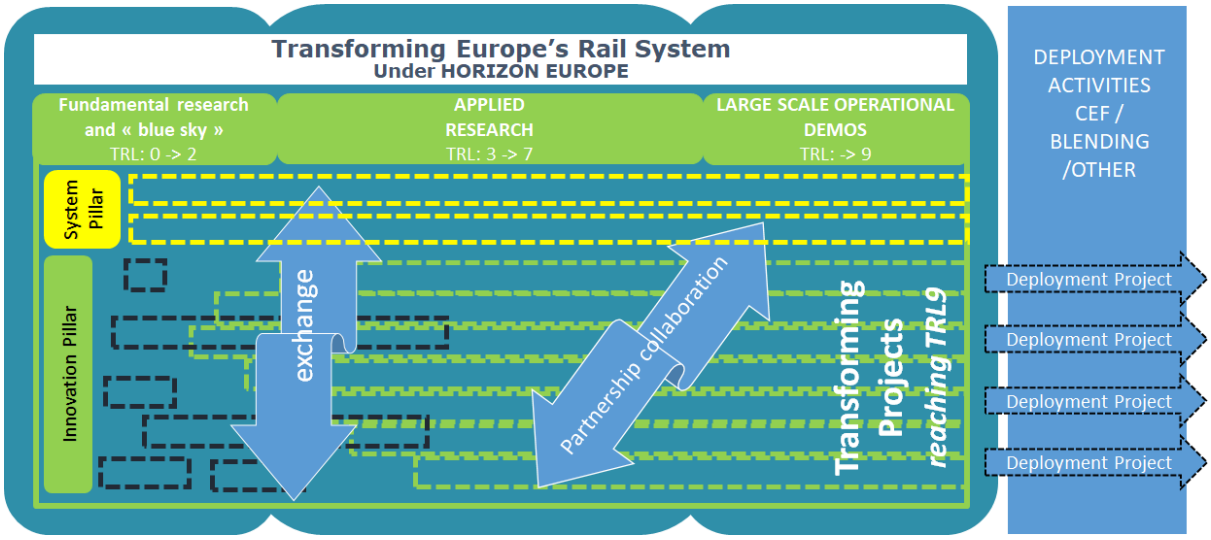
digital solutions, artificial intelligence, imaging, robotics, etc. but also addressing sub-components, e.g. mechanical, that otherwise would jeopardise the transformation to be delivered. In order to achieve such ambition, the Rail European Partnership should act as "single coordinating body" to ensure the convergence of the sector towards the aforementioned new Concept of Operations and the related Reference Functional System architecture, both addressing different segments. This would allow setting the right conditions towards modular (standard interfaces), scalable, plug & play, etc. solutions in view of large-scale market introduction and their evolution. It will require the necessary funding to involve key partners to deliver such a Programme, including testing results at different levels before bringing them at European large scale. It can be expected that funding estimated at around EUR 0.8 billion would allow building the organization around "core members" working together with "project members" and "participants" of all stakeholder groups to deliver an integrated and ambitious Programme.

- R&I Large Scale Operational Demos – this will be one of the major game changers in the impact to be achieved by the new Rail European Partnership. It is not about coordinating the funding, it is about Integrated R&I Large Scale Demonstration activities, i.e. moving from small-scale demonstrators [prototypes] in one specific network or lab, to European wide live, operational network-scale demonstration of solutions in a different environment, reaching TRL 9 level, and to show the benefits from the European deployment of new solutions. This will also be a key component for the inclusiveness of these areas of Europe, and consequently, Member States, under-represented in the current rail research and innovation activities. As they will be capable to contribute to the definition of specifications and demonstrating the benefits of the proposed partnership, or ongoing
- Programmes, solutions in their operational network and services offered to their customers. This activity will also support the necessary steps for the regulatory changes or standards' changes needed to bring solutions to the market, closing the virtuous circle started in the definition of concepts within the System Pillar, before industrialization and deployment. These activities are at the core of the Horizon Europe Programme, as demonstrated also in the past by other partnerships such as FCH and SESAR.

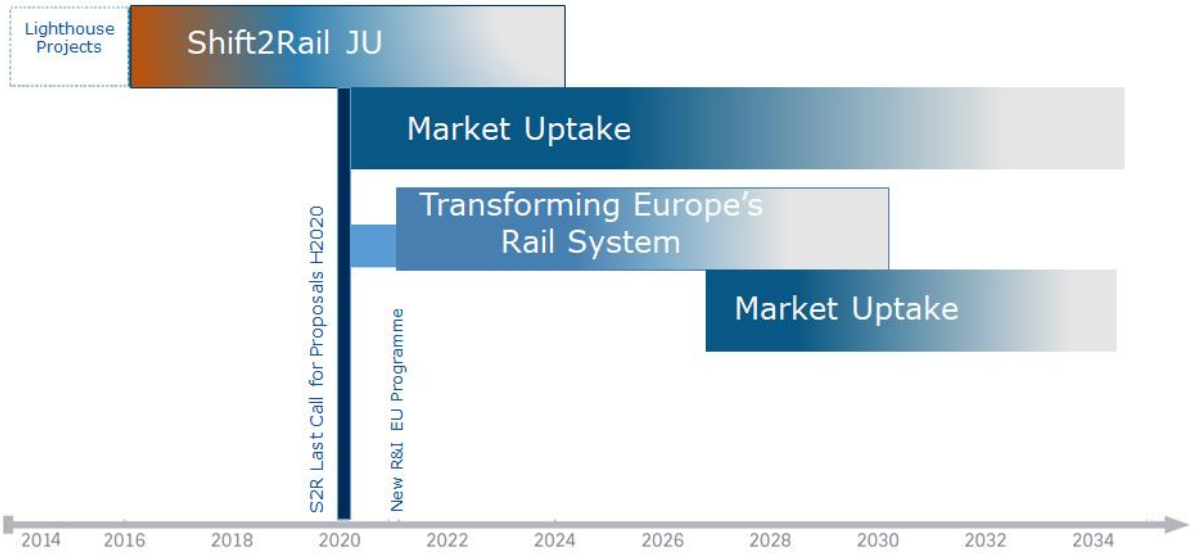
Nevertheless, the costs associated to these activities might be of key relevance and are estimated to around EUR 0.5 billion. This part of the Rail R&I European Partnership will be essential to fill the gap between different European systems, ensuring a modular approach adapted to the different contexts, from urban areas to high speed and corridors.

This Programme results from an integrated system vision and any possible arbitrary pre-selection of part of it would require the sector rethinking the presented delivery commitment and will lead to an unfocused approach – rather than one oriented towards achieving the targets for the final users.

The proposed Programme, in its three main integrated pillars can be represented as per below and it has an estimated value of EUR 3.3 billion depending on the underpinning conditions, today yet unknown. The estimated amount takes into consideration the scope of the Transforming Projects presented below, as well as the experience gained with an integrated Programme such as the S2R JU. To be noted that the overall amount of the new European Partnership depends on the extent and the scope of the activities to be performed. Impact and mission oriented focus will require to cover the full extent of the R&I lifecycle, associating regulators and having the availability of test tracks and revenue networks, which is estimated to require substantial resources. In the same manner, an inclusive European Partnership capable to put in competition proposals from different research activities to shape them towards a shared open model for deployment requires the extensive inclusion of stakeholders and dedicated governance.



Nevertheless, Horizon Europe funding will need to be complemented for the deployment of the output of the Rail R&I Partnership results with other European, national, or regional funding and financial instruments. This complementarity is needed to accelerate the market uptake uniformly all over Europe of the co-funded interoperable innovations. The Union should start with reserving a large share of CEF funding for the deployment of new Rail technological and operational solutions, including in urban TEN-T nodes. In addition, a revision of the current CEF regulatory framework should take place to mirror the evolution of rail operations, infrastructure, etc.



❖ **Phasing out strategy**

The Rail European Partnership is built around an R&I Programme that is designed to deliver innovative solutions capable of introduction to the market no later than 2031. As R&I is a continuous process, products and solutions from the Rail European Partnership with be fast-tracked to deployment; funding may be required to accelerate their market uptake, including phasing out of the technologies that they render obsolete. This approach will be embedded in the design of the Transforming Projects.

1.3 Necessity for a European Partnership

European Added Value of the Rail European Partnership

- The inherent advantages of railways – their ability to shift large volumes of passengers and freight swiftly and safely – with their unrivalled environmental performance gives them enormous potential as the backbone of a modern, sustainable, multimodal mobility system. This is increasingly recognised around the world. As a consequence, the position of global pre-eminence long occupied by Europe's railway supply industry is increasingly challenged, further frustrated by the railway sector's legacy of disparate objectives, systems and standards and consequent fragmentation. With a background of decades of underinvestment and insufficient focus on research and innovation, the sector struggled to maintain a place at the heart of Europe's modernising mobility system. Shift2Rail marked a turning point in the sector's fortunes, through the stable nature of the Joint Undertaking and the firm commitment of the Union, with its commitment to the creation of a Single European Railway Area. As well as, through equipping the sector with the confidence to plan for a future in which the potential of rail can be unleashed to the benefit of end users, passengers and freight forwarders and public authorities. It has inculcated new levels of collaboration throughout the railway ecosystem at European level – operators, suppliers, the research community, representatives of end-users and those who bring with them cross-sectoral disciplines. In so doing, it provided the supply industry with fertile opportunities from which to build on its global competitively and, to those responsible for planning the future of sustainable mobility, a credible route for developing the system for tomorrow. The need for the EU intervention stems from the Union's socio-economic and environmental objectives. These will be embedded in the next Rail R&I European Partnership. Realisation of these objectives requires coordinated collaboration across the railway ecosystem, single actors being unable to achieve them on their own or in the absence of significant investment in R&I to address significant market failure and the historic failure to achieve an integrated European Rail System.

- A Rail R&I European Partnership is essential for the support European research and innovation in the rail sector, increasing its impact through large scale operational demos and boosting integrated and sustainable mobility. The European Partnership will provide a coherent, unified voice for rail stakeholders: urban and mainline, helping to maximising the potential of rail research throughout the railway ecosystem.

The Rail R&I European Partnership will be enabled to meet the objectives of Horizon Europe and common political priorities of the EU and its Member States through a system approach. Through a initiatives, and the programme's objectives of the partnership.

The impact of the R&I would be enhanced by the legal format of institutionalized partnership. It would ensure that the contribution to policy design, regulatory framework and standards development, paving the way to lever greater investment in new railway systems. Having a European Partnership that is able to federate the R&I results and process them in a coordinated manner greatly facilitates developing better policy, regulations and standards within the rail domain (but not exclusively). Under the umbrella and direction of the EU, the relation with respective regulatory and standardisation organisations and specification setting platforms is therefore optimised with a dedicated JU. Similarly, cross-fertilisation of R&I activities at regional/national and EU level is greatly improved, as at least at EU level, duplication of activities is avoided and coordinated EU rail R&I expertise can be used under the frame of the JU.

In addition, all processes that relate to e.g. standardisation of rail system applications can be approached in a more coherent manner, developing new solutions that are interoperable by design and – at the same time –securing the market-uptake of such solutions.

A New Rail European Partnership should include in the research programme joint work with other modes of transport towards seamless and integrated public transport, shared research targets for rail in general and specific goals for the different rail segments. This can be achieved thanks to the exploitation of the rail system-of-systems, which is by nature a complex interaction between different technical sub-systems and actors. The new Rail partnership will optimise this through an integrated digital European Rail Traffic Management system. The proposed European Partnership will facilitate the optimal management of a truly European mobility through open and shared interfaces across all modes through the associated Reference Functional System Architecture, and thereby enabling the optimal management of a truly European mobility. Additionally, it will focus on delivering Large Scale Demonstration activities on services related to On-demand Passenger mobility and logistic for Goods, creating opportunities for partnership cooperation with other transport modes, across regions and cities.

The funding that will be provided by the Union through the next Rail R&I European Partnership will be the long-term **risk sharing contribution** that brings together the resources of the different stakeholders. It will serve to deliver the transformation through an ambitious and forward looking operational vision with a quick-win approach to start the transformational process. This is why ambitious targets are required both by the rail sector and by the strategic industries of Europe.

The next European Partnership will have also the objective to accelerate the market uptake through covering the full R&I value chain and moving from single technical sub-system demonstrators to operational system demonstrators in multi environments, to break down barriers faced in the deployment phase. This will be an essential component in accelerating the decision making of the operators and infrastructure managers, including urban, in upgrading their systems, phasing them out, looking at new disruptive solutions: this is answering a clear demand of the European citizens, framed by the European policies.

This process will not happen without the proposed Rail R&I European Partnership, which is also contributing, as institutional Union body, to the dialogue with national and European authorities, standardization bodies, international organizations in view of the acceleration of the market uptake through the establishment/change of the current standard and regulatory framework.

Looking at more exploratory research, there is a need to integrate more the research community to explore how technological solutions, scientific discoveries, etc. may be embedded in rail systems and contribute to transform them. It is a risk-based process and it should be a "fail fast" process to be challenging of the current systems. The Union funding will be also pivotal in testing competing ideas and solutions to create new market opportunities in Europe and at global level.

The institutional nature of the new Rail R&I Partnership would provide the sector with the necessary governance that would ensure the sector participating to the decision making process towards the convergence of solutions. In this respect, the European Partnership will act as "single coordinating body" bringing the whole sector together to develop Concept of Operations, Functional Reference System Architecture, and associated specifications and standards, consolidating, and coordinating current initiatives. It will require:

i. A clear mandate from the Commission with recognition of the centrality of Commission role to oversee developments, with ERA as CCS system authority to ensure that mainline and SERA outputs when relevant are processed into TSIs efficiently and ensuring safety and interoperability,

ii. Broad representation from the sector, including with the presence of technical bodies and associations and end-users' representatives from across Europe, with a voice in decisions taken,

iii. Inclusive governance – a guarantee that decisions will reflect objectivity and impartiality,

iv. Sufficient resources and decision-making capacity within the future Partnership.

The objective of this structure is to facilitate the process of bringing R&I technological and operational solutions to the market, providing solid and sector shared input for harmonization processes such as TSIs, standards. The model requires further refinement, not least to ensure appropriate engagement with Member States as also with members of the scientific community.

The proposed structure aims to provide a strategic, ambitious, and efficient approach by having a single coordinated process to define the operational concept and functional system architecture (under the policy guidance of the EC) and by defining requirements in cooperation with the sector and industry. By coordinating initiatives under a single umbrella, it should be possible to make the best use of scarce resources, both from the Union and others, financial and human and targeting linked R&I. The clarification of roles should assist with the systematic, fast, and timely development of products, standards, and specifications.

The governance structures within the future JU would be aligned with the expected outputs through establishing two pillars, a System pillar designed to best serve the development of the overall Concept of Operations and Functional Reference System Architecture. As well as, an Innovation pillar to deliver user focussed research, innovation, and demonstration, including delivery of projects providing well-defined input to the system pillar.

Finally, the Industrial perspective for competition at global level must not be underestimated: creating a solid internal market for rail R&I is a platform for global competition, especially in a situation where the level playing field, procurement rules, requirements to produce outside the Union may jeopardise the future competitiveness of the sector at all levels. Only an integrated European action intervening on the key pillars – regulatory framework, operational performance, workforce, research and innovation (including large live scale demonstrations) and deployment – will bring a major return on investment for the European taxpayers.

It is therefore through the new Rail R&I Partnership that railway can contribute to transforming mobility by integrating citizens, regions, and businesses, thus building upon European Union values.

How the partnership addresses the objectives of Horizon Europe and common political priorities of the EU and its Member States

- The section "General Objectives" includes all the elements on how the European Partnership will address the objectives of Horizon Europe and the common political priorities, please refer to section. More specifically, the multi-annual work plan will be based on a European Rail Master Plan for R&I that will identify more specifically the political priorities and challenges to be met by the work to be performed.

  The new Rail European Partnership will deliver results and impact addressing the Master Plan and creating a virtual circle on how the transport and mobility policy should evolve considering the progress achieved in research and innovation up to the final market uptake.

  The steering of the European Commission – DG MOVE in particular, will be essential to ensure that the general and specific objectives of the partnership remain aligned to the evolving priorities of the Union as well as the Partnership shall be instrumental to provide policy feedback as the result of its work.

- The new Rail R&I European Partnership, building upon the work initiated by Shift2Rail, will ensure the alignment of its activities with National and Regional Rail Programme of the Member States and future Associated Countries to Horizon Europe.

This will start at the setting up of the Partnership and the participation of Infrastructure Managers, inter alia, which will create a strong bond with National Programmes; similarly, at the level of railway undertakings and supply industry, it has already been experienced the leverage effect created by connecting Shift2Rail activities with national ones.

Also at institutional level, the role of the States Representatives Group is essential to provide input to the Partnership on the evolving needs, national programmes including in connection with other policy Member States' Committee, such as RISC.

The relation with the European Agency for Railways will be also a key element to favour the national and European research and innovation needs to be addressed.

❖ Finally, the proposed "System Pillar" within the new Rail European Partnership will be a key instrument to connect European policy making with the definition of the new concept of operations, to connect national systems in an integrated network. Such Pillar, where the stakeholders are represented beyond the specific membership, will be the opportunity to connect strongly the evolution of the European rail system with the integrated research and innovation activities needed to provide forward looking solutions toward the Single European Rail Area.

1.4 Partner composition and target group

❖ As much as the next Rail R&I Partnership will be built on and consolidate the achievements of the S2R JU, its membership and participation will require in depth re-assessment to be tailor made to attract the different groups of stakeholders, in particular those missing or with minor role in the current S2R.

In order to exploit the potential of the programme, and in view of the ambitions for it, the set-up of the partnership is designed to ensure the following:

- Comprehensive representation of the rail sector across the EU by adoption of solutions for all countries and markets, e.g. in freight solutions;

- Increased participation of SMEs, start-ups and end-users;

- Facilitation of cross-industry (e.g. energy, telecommunications, IT), inter-modal (e.g., road transport, maritime, logistics, aviation) and cross-sectorial sharing of technology and know-how;

- Access to the research and innovation opportunities of the future (institutionalised) partnership for any interested European rail stakeholder.

The proposed structure recognizes the role of the systems' different actors.

❖ **In terms of target groups and stakeholders, the following need to be involved in the new European Partnership:**

- **The Operating Community**:

  - European rail infrastructure managers who are responsible for the European Rail Network etc.,

- Rail undertakings who operate trains (both passengers and freight) and sometimes infrastructure and constitute the interface with society, offering MaaS, etc.,

- Urban Operators who manage the urban and in many cases suburban rail operations (metro, trams, light trains, etc.) in cities, regions and sometime cross-border, together with other services and modes of transport and integrate them within smart cities.

The operating community is the interface to society, interpreting the needs and aspirations of end-users – passengers, freight-forwarders and public authorities and finding ways of giving cost-effective expression to these operationally while the supply industry, supported by the scientific community, provides the equipment with which to do this.

- **The Supply Community,** comprising manufacturers of rail systems or components, contractors and service providers (e.g. maintenance activities) whose research and innovation activities are established within the European Union or in the countries associated to the future HE programme, covering the full spectrum of the value chain, from SMEs to large integrators,

- **Start-ups** which can introduce agile innovation within the rail system, including those coming from different branches of activities,

- **The Scientific Community** represented by universities, research centres, providing knowledge as well in rail related as in other technical areas, e.g. communication technologies, where solutions can be adapted to be used in tomorrow's railway systems. Further, the schools are important since they educate the people that are going to work at the stakeholders described above.

- **Freight** forwarders and **logistic** service providers,

- **Passengers and Freight forwarders** represented by European and/or national associations,

- **Representatives of rail staff**, as staff expertise and involvement in the transition processes will be essential in the ambitious transformation of the rail system.

- **National Supervisory Authorities and relevant bodies** and initiatives in charge of promoting national Rail R&D activities, such as National Technology Platforms.

- Public authorities in charge of PSO and multimodal integration of mobility services at urban level.

- **ERA** to ensure that research results support and are consistent with the development of SERA, to facilitate the development of cost effective approaches to meeting the interoperable railway essential requirements, and to close open points in the European Legal Framework.

- **EU standardisation bodies** (e.g. CEN, CENELEC and ETSI) to act on the outcomes of research and innovation activities generated by the partnerships to facilitate the evolution of EU regulation, and to anticipate standardisation activities that can accelerate the market-uptake and remove barriers.

- **Sector Associations and technical bodies of the different stakeholders' communities here above listed and trade associations,** which federate around themselves large communities of rail and public transport related actors. They can also contribute in different ways to accelerate the convergence of the sector towards R&I innovative solutions, their testing and

future market uptake; dissemination and communication of results, development of cost-free sectorial technical documentation supporting future deployment and operations, etc. can be critical in the success of the new Rail R&I Partnership impact**.**

The success of the new Rail R&I Partnership builds upon the inclusiveness of all the actors in the sector and the adequate recognition of their role; it requires a focused core membership and inclusive participation. This must lead to improved and advanced technology, component, and system specifications, as well as changes in operating procedures and governance requirements at multiple levels allowing their full exploitation.

❖ **Proposal: types of members and participants to the core activities of the new Rail R&I European Partnership**

The Partnership should reflect the need for flexibility in participation – possibly varied to meet the requirements of particular tasks in hand. A "one fits all model" is not necessarily the best solution: for example, there may be a case for reflecting the 'Twin Pillars' of a System pillar designed to best serve the development of the overall Concept of Operations and Functional Reference System Architecture, and an Innovation pillar to deliver user focussed research, innovation, and demonstration. Whatever model is finally chosen, it must be fit for purpose and support the concept of an agile Rail European Partnership.

- **Core (Founding) Members** (list to be annexed to the Regulation or secondary legislation such as Commission Decision);

  The proposed partnership could have a number – indicatively up to 15 - of core [in the current JU legislation Founding] Members with participation in the full programme. These represent the sector in a comprehensive and balanced manner, i.e. representatives of the European Rail Supply Industry, Railway Operators and Infrastructure Managers including urban stakeholders, as well as universities and research centres, in the form of Linked Third Parties.

  It is expected that the Core Members:
  - Commit to large part of the Programme content, bringing extensive expertise in its different components,
  - Consider collective gross contribution of at least EUR 1.0 bln, subject to the overall funding and conditions that will be made available in the new Rail European Partnership and with a minimum average gross contribution of EUR 60 million

  At the end of June 2020, the Core Member candidates are largely stemming from the current Shift2Rail partnership[24] together with additional entities which have expressed the interest towards a long term commitment based on the elements here above. As already indicated, the need for a balanced representativeness of key stakeholders' categories as well as geographical balance will have to be matched by single entity decision and preparedness.

- **Associate Programme Members** (the entities working in the European Partnership as a result of the award of Calls for proposals and/or tenders so identified) , including:

  - **Associate Project Members:**

    Associate Project Members should work together with the Core Members to help finding solutions to the R&I challenges of the Programme; they have more flexibility in that they

[24] The Shift2Rail Joint Undertaking Founding and Associated Members are listed here: https://shift2rail.org/about-shift2rail/ju-members/

can commit to specific parts of the Programme bringing specific expertise with also a different participation in the governance and a commitment per content/activities, possibly linked to specific phase(s) of the Programme. SMEs, representatives of the European Rail Supply Industry, research centres and universities, operators with extensive R&I activities, other legal entities such as technical bodies of the sector, etc., are expected to/can become Associate Project Members.

- **Other Associate Project Partners:**

  This category is created to specifically attract some railway operators and infrastructure managers today not represented within the current S2R JU and which would be more interested to participate in a) the definition of specifications, and b) test innovative solutions. Their interest will be addressed in designing attractive forms of participation in the programme activities, subject to the funding and conditions of the new European Partnership, i.e. certain control mechanisms may need to be established so that a theme or an area does not become a technical niche/silo of well-entrenched 'usual' participants, impeding cross-fertilisation. For that, the transparency character of the new European Partnership plays a major role.

  The participation of urban rail stakeholders (operators, local authorities) would be ensured by making the Rail European Partnership properly address local public transport needs and constraints.

- **Any Other Third Party:**

  Any other entity not listed here above which can join the programme for example as subcontractors or contribute in specific areas outside the Programme membership. For example, there will be potential to establish links/ and collaboration opportunities with other new Horizon Europe partnerships, (safe and automated road transport, HPC computing, air traffic management and aviation, ECSEL components and electronic systems, Fuel Cell Hydrogen, batteries, steel, space, etc.), other parts of the Horizon Europe Programme, (e.g. in the context of cities mission or the EIC – EIT KICs).

  This category of participation might also be covering the needs of participation to the activities planned within the specific System Pillar, following the selection procedure linked to the dedicated funding.

As indicated, this membership structure is proposed with regard to the core activities of the new European Partnership, covering the full value chain of the research and innovation but mainly large parts of the applied research and large-scale demonstrations.

With particular regard to low level of TRLs (1 – 2) or the large scale demos (TRL 7 to 9), it is expected that these activities can be performed independently from the "membership status" identified before. In fact, low TRLs will require the extensive participation of the scientific community while the Large Scale Demos will require the involvement of operating community that may have never been involved in the R&I activities but will need to be integrated in the future deployment of innovative solutions.

❖ **Geographical focus, pan-European reach**

The proposed Rail European Partnership will include entities from the Member States and associated countries in Horizon Europe, reflecting the importance of a wider integrated railway system and to facilitate demonstrators and deployment across the EU.

Responding to the recommendations of the H2020 interim evaluation of S2R JU, it will particularly seek to broaden membership base with entities from countries that have not been involved yet; the large scale demonstrations will be key in creating opportunities for participation for entities more focused on systems' innovation.

The "other project partners" category is intended to enable *ad* hoc participation in specific activities – for example, the opportunity of involvement in large-scale demos can attract participants from key European areas today not involved in the S2R JU. This will also require breaking-down language barriers, offering the opportunity for local approaches while introducing European interoperable solutions, etc. and a combination of R&I funding, cohesion and regional funding, EIB possible intervention and any other form of intervention that would accelerate the return on investment at a faster pace.

The participation of future Associated Countries to HE will be essential as the European rail network goes well beyond the European Union and is an element of connectivity in logistics - and to a certain extent passengers covering the Asian continent, GCC, and possibly Africa. The new European Partnership will work under the umbrella of the External Action policies in meeting connectivity and integration expectations. Many of the industry members are already operating in these territories and they may have a business interest in involving Associated Countries' operators in testing and deploying new innovative solutions.

The work performed by the Rail European Partnership will evolve as it adjusts to changing user, sector, and policy needs. There needs to be an inclusive approach towards the non- member stakeholders who may have a useful contribution to make to discussions. Technical working groups could be created, and together with European Technological Platforms – like ERRAC – leverage their knowledge to advise on future priorities and activities of the rail European Partnership.

- **International relations**

The current S2R JU is in the process of establishing MoUs with similar organizations established in Canada, Australia, Japan and USA. Some of these negotiations are more advanced; others will require more clear definition of the scope of the collaboration. In addition, extensive exchanges are ongoing with the Federal Railway Administration, American Public Transportation Association, Non-Traditional and Emerging Transportation Technology (NETT) Council and the Federal agencies in the USA, as well as integrated new rail projects.

The scope of such exchanges and collaborations spans from sharing experiences and the results of demonstration activities to developing opportunities for twinning projects in areas of common interest.

2 Planned Implementation

2.1 Activities

The Interim Evaluation Report on S2R notes that the scope of the activities identified by the Master Plan, is still considered relevant. At the same time, it highlights various recent trends in transport markets (including autonomous vehicles, car-pooling, robustness also under severe weather conditions and Mobility-as-a-Service - MaaS), driven in part by new technologies, which are likely to affect the demand for rail travel and were not necessarily anticipated at the time the Innovation Programmes (IPs) were developed. It will be important to consider the implications of broader trends in technology and innovation and in end-user behaviour for the focus of future rail research and for its sponsorship and management, as S2R has already started including in its programme through the a new dedicate Innovation Programme (IPx).

Taking into consideration the Union priorities, the identified General and Specific Objectives, the new Rail European Partnership R&I Programme could be based on the following initial areas of work (up to TRL 9).

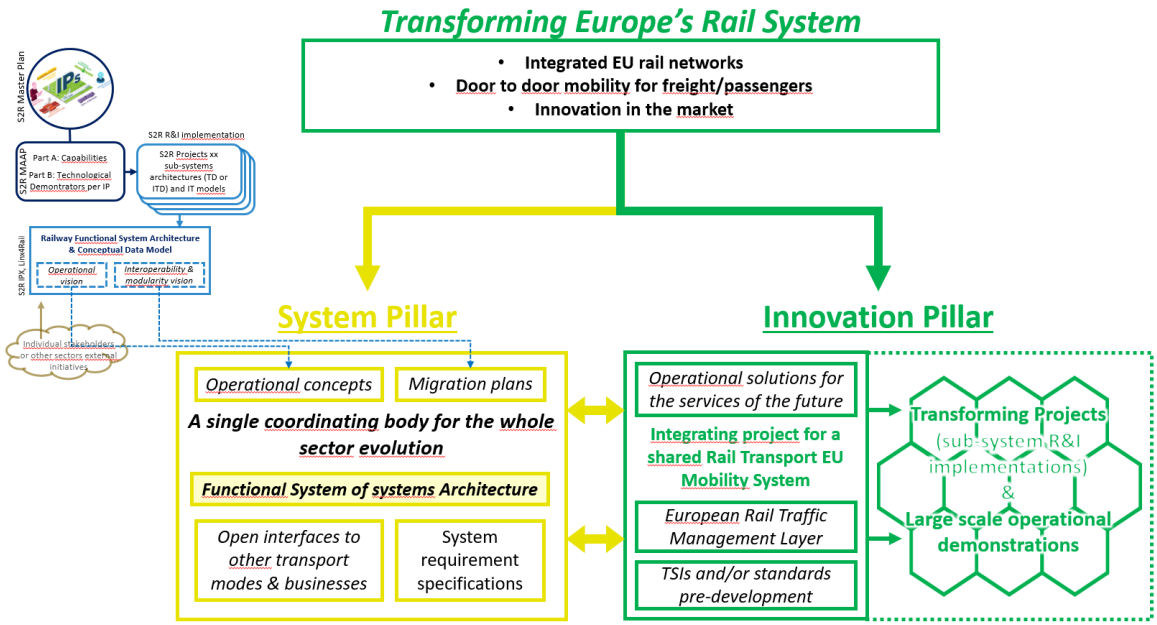
It should be noted, that they are provided as structured ideas of the different areas of innovation, in view of their future deployment, that the sector recognises as a priority. All activities that will be undertaken in the European Partnership will be "user first" oriented, designed to deliver those capabilities that the rail sector needs[25] but, **for the first time, within an integrated system approach.**

In order to respond to the user demands for high quality, on-demand, door-to-door mobility/delivery that is resilient, reliable and seamless, rail needs first to target the global performance, which definitely requires mastering, designing, simulating and testing through R&I the Railway System as a system-of-systems, including its connection with other transport modes.

- **An agile and evolving Programme aligned to an ambitious Strategic Research Agenda for Mobility and Transport: Initial working areas within two dedicated Pillars**

The European Partnership Programme will need to be implemented in an agile manner, designed to deliver by clear deadlines with associated business/societal cases.

[25] See S2R MAAP Part A : https://shift2rail.org/wp-content/uploads/2018/04/Maap_2018_FINAL_2.pdf



- **The System Pillar**

The starting point should be the revision of the Concept of Operations for the different rail segments, with an integrated mobility and transport approach, recognizing the specific nature of each segment, hence, the relevant interfaces.

The implementation of the shared vision shall cover how to design and operate the rail systems in the short, medium, long-term, deliver migration strategies, look forward to European wide deployment and strategize market implementations, over each transformation decade through to 2050. It is also driven by the Horizon Europe impact focused approach, which requires a systematic approach to speed-up adoption of solutions for their future deployment in the rail systems: it is about convergence and, when needed, standardisation but also addressing the migration processes to support the transformation of national systems with different levels of performance, reliability, robustness, safety and operations.

This will be the basis for a system of systems approach, building upon a wide Reference Functional System Architecture, starting from and focusing initially on a harmonised Control Command and Signalling approach and dealing with the interfaces with other modes of transport, such as urban rail as integrated system within urban mobility.

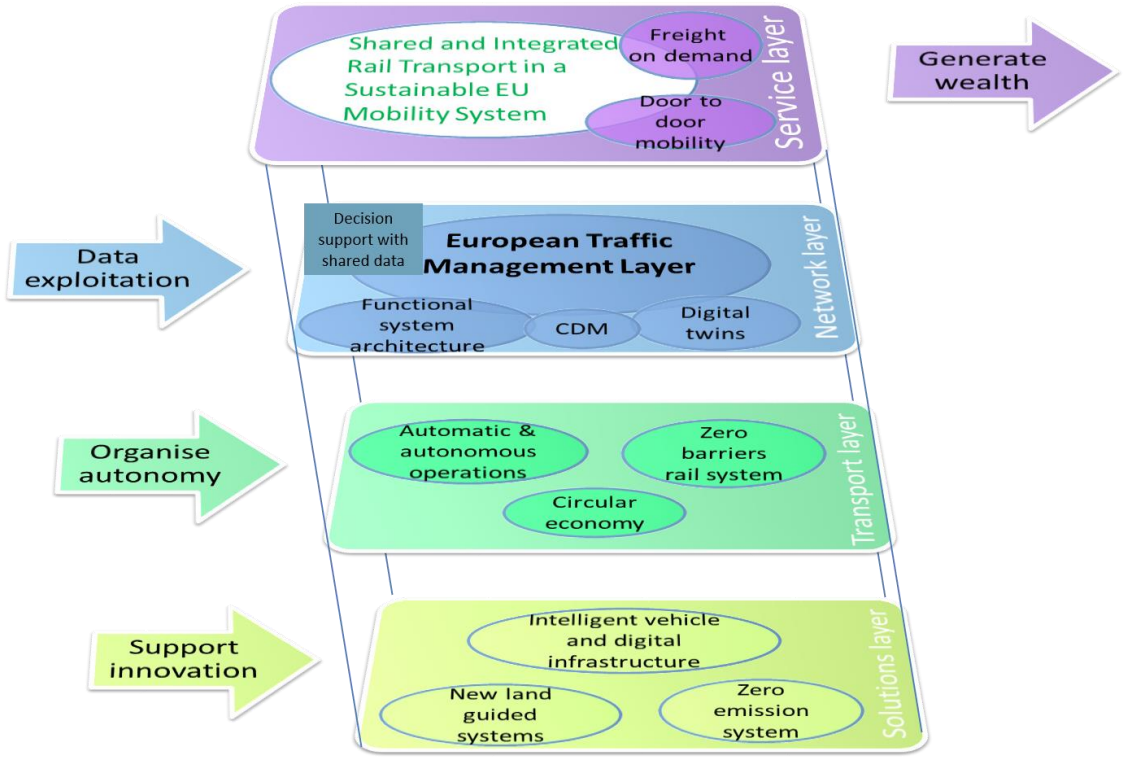
The System Pillar

- is necessary to provide a framework for the evolution of the system and the associated research and innovation,
- allows Partnership to act as the single coordinating body to bring the whole sector together to develop operational concepts, functional system architecture, and associated specifications and standards, consolidating and coordinating current initiatives (RCA, EULynx, OCORA). It will also allow addressing specific interfaces,
- is flexible enough to integrate businesses and services, scientific and technological (digital) evolutions, whilst ensuring the coherence and continuous operation of the Railway system all along these evolutions,
- to be referenced to the current state of play and legacy of the Railway sector, in order to enable managing the transitions and possibly ruptures and leaps needed for the business evolution of the railway sector (Migration plans),
- to guarantee to all stakeholders access, openness and transparency insofar as needed for businesses, but also managing the stakeholders IPRs and being as secure as the state of art and its evolutions (Cybersecurity). Digitalisation and shared data are enablers for automation

and for inventing and evolving a shared reference functional rail system architecture; they will be essential in the solution of complex problems involving many diversified actors.

The current S2R JU has started working on the Reference Functional System Architecture (which is encompassing all subsystems, including CCS) to depict the structure of enablers and solutions created during its remit, their relationships, and the principles and guidelines governing their design, functional evolution over time. This paves the way for a consistent, resilient, reliable, interoperable and cost-effective system deployment. Yet it does not cover all the interfaces, for example with urban transport. This provides the basis on which solutions can be developed that contribute to integrated urban mobility, in close collaboration with the other urban mobility solutions and services.

The proposed Rail European Partnership will approach R&I with a holistic view of how at the different activities that will be undertaken fit into the future shape of shared and integrated rail transport and mobility. As a result, the scope of the System Pillar will evolve during the time to cover the rail system at large, subject to the necessary resources made available to deliver it. The ultimate purpose is to improve the current system and transform it, so that new and additional wealth can be generated out of their exploitation. The new Rail R&I Partnership is needed to enable this sectoral evolution and a first vision of the interconnection and architectural integration of the initial working areas is depicted below:



Not all layers apply in the same manner to the different segments of the rail systems and the chart should be read in such context.

A consistent system-of-systems approach will deliver "door-to-door mobility", "on-demand door-to-door mobility" and integrated logistics. It will build upon integrated intelligent rail freight, through the introduction at local, regional, national and European level of technological solutions and operational concepts that maximize the performance of the services provided to the passengers and freight clients. Providers of the different rail service segments will be involved in this and expected to ensure that it reflects their needs and thinking.

This will help to identify those areas where Urban Rail will develop independently or in a way that is coordinated with the needs of the mainline network. This work is then complemented by works on standards, on the definition of harmonized common specifications, and on regulatory and policy aspects.

Through the System Pillar, the rail system and its underpinning regulatory framework will not be driven by technology but by the needs to meet the expectations of the different categories of users. It will be designed to be able to evolve with scientific and technological developments, without requiring obstacles faced by the deployment of current and future solutions first to be solved.

- **The Innovation Pillar**

The Programme "Innovation Pillar Integrating Project"

With the creation of a dedicated System Pillar and based on the experience within the current S2R Programme, there is a need to ensure an interface between the System Pillar and the different Transforming Projects that will perform the R&I activities. The "Innovation Pillar Integrating Project" will support the Programme Board to answer the requests coming from the System Pillar with a coherent and consistent approach, addressing change management processes as necessary. The current S2R Project Linx4Rail includes inter alia, activities and has demonstrated to be improving the overall efficiency of the Programme. Consequently, the "Innovation Pillar Integrating Project" will be capable of ensuring

- the exchanges with the System Pillar,
- the coordinated integration of the Transforming Projects and their interdependencies to maximize the benefits of the innovative technological and operational solutions, in line with the expectations of the System Pillar,
- and the development of possible specifications (in TSIs) and/or standards.

Given the opportunities provided by digitalization, it appears obvious that, similarly to other transport sectors, rail should exploit the possibility to offer to users a coherent shared ecosystem that leverage from the synchronisation of input and output of different sub-systems.

The Programme "Transforming Projects" (also TPs)

Innovative solutions delivered by the Transforming Projects in the architecture concept framework allows creating new mobility services, integrating the different rail systems and recognising their specific context, for the user of the future, addressing the inherent problems that are currently affecting railways and providing an optimum global transport system.

Here below an initial list of proposed Transforming Projects to deliver the expected impact on future mobility and transport. The detailed description for most of those is attached in the annex. These areas of work will be further assessed in shaping the content of the proposed Rail R&I European Partnership.

1. *ETML (European Rail Traffic Management Layer) and European Rail Network Manager* – Based on building upon the high performance Reference Functional System Architecture for the traffic management and to secure exchange of information between the key actors of the mainline rail systems and other rail segments and sectors. It is similar to what has been achieved in shipping and aviation but with a wider European mobility perspective, this area will create the basis for integrated solutions.

2. Assets for *Automated and/or Autonomous and/or remotely piloted Operations* aiming at deploying some pilot cases that will be evaluated for market readiness, leading to certification. Full automation and connected systems bring the opportunity to generate a step change for rail systems and more sustainable urban mobility. However, there was a big step towards automation long time ago (metros and commuter railways). The next quantum leap in urban rail is to add autonomy features in trams and LRT (in cooperation with the other users of the urban space. This would allow trams to run (semi)-driverless. Also metros could become "smarter" (self-train recovery, autonomous workshop or OCC). In addition, freight operations will benefit from automation.
3. *Railways Digital Twin, Simulation & Virtualisation,* dedicated exclusively to the development of the enabling technology "railway digital twin". This working area will generate coordinated and compatible models and techniques that will be the basis for an appropriate approach of the various rail market segments based on the Reference Functional System Architecture. The digital twins built and demonstrated at system and subsystem level will be applied to several areas with high impact to business performance. For each rail market segment, digital twins of rail objects will cover all modules of relevant sub-systems (vehicle, infrastructure, power supply, signalling…). As well as, their interfaces and interactions and are therefore populating the Reference Functional System Architecture.
4. *Smart Asset Management and maintenance of the future* - for maximising the possible impact of digital transformation, railways will be regarded as a system of systems, although recognizing the specific aspects of urban rail, as well as a fundamental part of the broader framework of multimodal transport in the integrated European transport market. New and emerging technologies have started to impact the transport and rail business: while ubiquitous sensors and diagnosis tools have been available for major new rolling stock components for more than a decade, big data analytics, internet of things, machine learning and soon Artificial Intelligence will permit clever and timely interpretation of data into meaningful information. At the same time, fixed assets (infrastructure) are also fitted with smart measurement devices. This will lead to a radical transformation of the business planning, operation and maintenance activities and deliver increased asset availability and cost-efficiency driving the sector from diagnosis to prognosis maintenance in each rail market segment.
5. *Smart Integration for door-to-door Mobility* will drastically improve the integration of railways in the overall European mobility ecosystem, making it the natural backbone of mobility between cities and for medium and long distances. As regard urban nodes, medium and long distance services will be properly coordinated with inner ecosystems providing a priority for mass transit and shared services while integrating the new opportunities of, Mobility as a Service schemes operative across all modes, including micro-vehicles.
6. *Emerging Transport Models and Systems (Moving Infrastructure System (pods)/MaaS, hyper speed systems)* will address a Game Changer for Railway Transport and other transport modes. The challenge will be to change the transport offer of public transport to a truly multi-modal concept in a collaborating public transport system.
7. *Environmentally Friendly and Attractive Sustainable Mobility* – the rail industry needs to understand the impacts and mitigations for development and supply of new technology. All solutions need to be commercially viable and/or sustainable by the society with a reduction in the total cost of ownership. Solutions should have the ability for upgrade to enable the implementation of new technologies. There should be resource efficiency, for example, a high level of recycling especially spare parts through the system lifecycle. They will need to consider the relation between energy efficiency, total consumption and impact on the passengers, in particular in the urban segment. The greening of infrastructure is a core issue, in design, replacements and operation.
8. *Rail as the backbone of a green freight logistic chain* – increasing the capability and capacity of rail freight is a top priority. One core element of the transformation to logistic

on demand services is the link between customer demand and logistic service supply. This requires seamless, digitised customer communication linked to the management systems of RU, IM, ports, clients, and multimodal service provider to a [rail] freight communication ecosystem. Automation and digitization of freight train is the core, but also its operations, yards and intermodal terminals based on real time data are areas which further of R+I developments requires.

9. *Network management Planning and Control:* Digitalisation and shared data are enablers for automation and help to solve complex capacity problems with many involved actors. The aim is to have timetables and operational traffic that are connected, optimised, resilient and punctual and still deliver high capacity utilization. The main scope is to develop the planning and control aspects of network management. This Transforming Project is linked with the one on ETML and its evolution to be considered in this respect.
10. *Socio-economic area* – there will be a dedicated area that will consolidate all the input coming from the different operational projects on horizontal aspects. As well as dealing with staff, social impact, behavioural change (e.g. such as changes in working and shopping patterns accelerated by Vovid-19), gender balance, HMI, digital business, business case models in each rail market segment and each TEN-T node, etc. The objective of this area is mostly identifying the activities embedded in the R&I areas but at the same time recognizing the need to consolidate the results at Programme level, applying consistent methodology and approach. This area of work may also include dedicated activities in liaison with other European Programmes concerning training and education (e.g. Erasmus +), to ensure an alignment to them and benefit from such integrated experience.
11. *Safe and healthy mass transportation area* – this area will focus on the railway sector's approaches to ensure safe and healthy mass transportation by trams, metros, commuter- and regional trains, Intercity and High Speed trains, for passenger and freight transportation. There is need for R&I activities regarding layout and management of train stations and platforms, layout of conventional rail vehicles, and for freight transportation all degrees of automation in depot and on track and in all operational conditions. Also all level of operations, from contingency up to re-start should be considered.

These Transforming Projects may be complemented by other more specific technological or scientific activities including aspects that may contribute to accelerate the transformation, cost reduction and sustainability of the rail systems related to materials, construction, design and construction of fixed assets, design of terminals, new concepts of stations within the smart cities. These areas may also be an opportunity to be linked to the new Rail R&I Programme to other European Partnerships, activities and programmes, such as the Missions (e.g. Smart Cities) or EIT-KICs (Energy, Mobility, Climate, etc.).

Each area may cover the full spectrum of rail research and innovation and result from work performed from a combination of members, project members, other participants, etc. They can belong to Infrastructure Managers, Operators, Manufacturers, Research Community at large and include cooperation beyond the Union borders (see also the following sections).

The Programme structure will be designed once the combination of governance, funding and content will become clearer. This will be also the opportunity to identify how to integrate the different R&I areas and where to have dedicated work-streams per segment.

❖ **Implementation approach**

The structure of the Rail European Partnership is integrated Programme in two Pillars allows for dedicated implementation approaches to answer specific needs.

Beyond the ad hoc governance, the work to be performed in the **System Pillar** requires specialized expertise from the sector acquired via calls for proposals and/or tenders that would ensure to

- Work in a verifiably open, impartial, non-discriminatory, objective and transparent way, with outputs not subject to IPRs from individual contributors,
- Recognise the competences of each stakeholder, starting with the operational experience and needs of Infrastructure Managers and Railway Undertakings, design/technological development competences of suppliers, etc. so that the definition of the concept and proposed solutions are shared and pave the way for faster deployment,
- Allow sufficiently representative participation across the sector, including joint funding of work carried out by IMs, Operators and suppliers,
- Ensure the necessary speed of R&I development,
- Ensure quality of output,
- Starting from CCS and, in this respect, build on ongoing on-board and track-side CCS and wider architecture, integrating RCA/OCORA and UIC FMRCS project, including the collaboration with Eulynx, railML, BIM and RTM so as to come to a unified work strand for the SERA; ensure the necessary external interfaces' management,
- Prepare the necessary elements supporting migration plans, future regulatory framework or standard, if and when necessary,
- Support the set-up of large scale demonstration activities to prove the validity of the identified solutions and gain a rapid experience on the operational concept taking account of the requirements and decision thresholds provided by ERA,
- Provide the necessary framework to ensure the required "evolutive maintenance" of specifications, with the support of all relevant and qualified resources, in view of their future upgrading, in agreement with the Commission and ERA.

With regard to the **Innovation Pillar**, the implementation via integrated and agile Transforming Projects allows covering the full cycle of research needed to result in concrete solutions that would ensure delivering a clear impact at their end, as well as intermediary deployable results during their different timeline stages and technical complexity (typically the different level of ATO, for example).

The Innovation Pillar Integrating Project will support to understand how to deal with technological and operational enablers that are cross-cutting different Transforming Projects and consequently may impact them in different ways.

Demonstrations will support the necessary increase of data sharing. By this way, innovations will be promoted and processes will be improved.

In addition, Transforming Projects will not result in vertical silos and they should bring concrete results with impact by mid-term of the new Rail European Partnership. They should be open to evolution, considering the progress in science and technology, benefit from other Programmes – national, regional or EU or other partnership activities. They should be open to adjustments in their participation and they should not have barriers between Members and participants in Programme activities (on the contrary to the current S2R Programme where there are artificial barriers created by the Regulatory framework between R&I activities of Members and non-Members of the JU, addressed by the complexity of collaboration agreements).

The main difference compared to the S2R Innovation Programmes is that a transforming-project starts from a challenge for the rail sector and its aim is to solve this challenge. Transforming Projects also cover all relevant aspects needed for delivering the solution, including economics, deployment evaluation, socioeconomics and regulatory issues, etc. Also, a clear accountability to deliver the results is not so evident in the current IP structure. In fact, the IPs are a way to group logically together technological demonstrators and keep a certain coherence, but afterwards, the achievement of the technological demonstrators results from the CFM & OC Projects' Consortia (silos).

The S2R has formalized in a Programme Board the coordination of the R&I activities to address change management, coherence, commitment to accelerate the progress and impact of the Programme.

It should be also noted, that some parts of Transforming Projects are transversal and may cover the full lifecycle of R&I or only part of it. It should be clear that membership and participation will not correspond to the lifecycle of research but is brought together to deliver clear impact. It might be that there will be particular areas available to attract third parties on more exploratory solutions or test solutions/technologies ready for future deployment.

The participation to the Transforming Projects will result from the commitment of the different categories of parties active in S2R and the correct "public tender/grant" procedures to ensure equal treatment and transparency. In addition, the participation can take place at different stages of the lifecycle of the Transforming Projects and evolve during the time.

❖ **Multi-annuality**

The approach of multi-annuality will be integrated to allow for an efficient Programme implementation, through the implementation of the "instalments" as established in the Union General Financial Regulation.

The overall implementation of the proposed Rail European Partnership Programme will result from the combination of funding and governance to deliver the ambitious content described in this document.

2.2 Resources

At this stage of the process in view of the establishment of the new Rail European Partnership, it is important to highlight here that there is currently no Commission proposal for the institutionalised partnerships, and thus no formalized indications from the Commission on the key elements underpinning the legal structure. Nevertheless, based on existing experience, the results of the different evaluations on the current Institutional Partnerships, the sector has developed the following proposal.

It is expected that the type of investment made by the different parties in the new Rail R&I Partnership results from the nature of their commitment. Investment capabilities of some stakeholder categories (e.g. urban operators or smaller members of the railway operating community) will never reach, even by far, the level of others. For this reason, a flexible and open framework should be implemented that allows non-members to work with Core Members. This would be also reflected in the procedures set up to award the activities that on the one hand, will recognize that in the Rail partnership, the Core Members, of which the Union is the essential party, need to be clear about commitment and expectations. On the other hand, taking into account the new policy to R&I partnerships, it will attract in the most appropriate manner those interested in working in different phases of the Programme or R&I.
In broad terms, the Commission services indicates that resources contributed by the private side should be:

- In-kind contributions to the projects funded by the Union contributions (on the basis of non-reimbursed eligible costs);
- In-kind contribution for additional activities foreseen in the Master Plan not covered by Union funding;
- In cash contribution used to finance the administrative costs, in case of an Institutionalised European Partnership (Joint Undertaking).

With regard to the Members' in kind contributions, it is considered that the use of total costs determined on the basis of international accepted accounting principles would simplify the approach and avoid inequalities between different categories of stakeholders (for example, private entities such as suppliers or operators versus public infrastructure managers

- **Core Members:** the net contribution of the Core Members to the European Partnership[26] will consist of the difference between the Total Project Costs and the funding received by the Partnership, which is requested at a minimum level of 50%. The Core Members Total Project Costs are expected to consist of financial resources invested in salaries, assets or their use, proving grounds, involvement of third parties (possibly also start-ups), etc.

  Core Members will contribute with "in kind contributions for additional activities" connected with the Master Plan but not covered by the Union funding and supporting also the acceleration of the delivery approach.

- **Associate Programme Members in the forms of Associate Project Members :** the model should be similar to the one for the Core Members, but with a lighter administrative process, with a funding rate at 50% and possibly In-Kind contribution to Additional Activities (IKAA)[27]. The use of lump sum could make easier the administrative effort.

  In general, Urban Rail Operators and smaller members of the railway operating community would be unlikely enter in a structure requiring high administrative effort, long-term perspective, and European-wide scope. Urban rail stakeholders (operators, local authorities) would be involved at "project level" (for example participating in the definition, design test and validation of a specific solution answering their needs) by ensuring the Rail European Partnership properly address the local public transport needs and constraints.

- **Associate Programme Members in the form of Other Associate Project Participants**, which, as indicated, will contribute to the definition of specifications, and possibly testing the overall results; the funding rate might differentiate compared to the activities to be performed.

- **Other Third Parties** will be subject to the H.E. funding rates for RIA, IA, or CSA, mostly involved in lower TRLs or possibly in the highest ones.

- **Financial Contributions** – beyond the net internal contributions to be provided by the different categories of members, it is expected that they would get involved with cash contributions to the running costs of the new Rail European Partnership based on the value of their net contributions, in a % estimated between 3 and 5%.

The establishment of any additional form of ''cash'' contribution from members risks being unworkable in practice. It will be a major obstacle for agreeing on the Rail European Partnership if it is to collect in a common ''pot'' the necessary ''cash'' resources from the participants and redistribute them. Moreover, some participants cannot be forced or even allowed to contribute their fair share, giving rise to ''free-riders''.

---

[26] Defined as IKOP in the S2R Regulation, Article 4(4): *For the purpose of valuing the in kind contributions referred to in point (b) of paragraph 2 of this Article and Article 16(3)(b) of the Statutes, the costs shall be determined according to the usual cost accounting practices of the entities concerned, to the applicable accounting standards of the country where each entity is established, and to the applicable International Accounting Standards/International Financial Reporting Standards. The costs shall be certified by an independent external auditor appointed by the entity concerned. The valuation of the contributions may be verified by the S2R Joint Undertaking should there be any uncertainty arising from the certification. For the purposes of this Regulation, the costs incurred in additional activities shall not be audited by the S2R Joint Undertaking or by any Union body.*

[27] except for non-profit research organizations

In any case, no decision regarding the type of contribution of private partners should be beyond the current proposal on H.E. Regulation, agreed upon by the Council and European Parliament in April 2019. Annex III ''Partnerships'' (1) (e) of the Horizon Europe Regulation states that, for each institutionalised European Partnership, a share of the contributions from private partners will be in the form of financial contributions aimed primarily at covering administrative costs, as well as coordination and support and other non-competitive activities.

With particular regard to the **System Pillar**, as already indicated, there is a need to bring the whole sector together to develop the operational concepts, functional system architecture, and associated specifications and standards, including consolidating and coordinating the diverse national / multi-national ongoing initiatives. The participation of different associations, technical bodies, public and private entities to the System Pillar will require to assess the best implementation way and legal set up.

Particular attention will be paid to increase participation of SMEs and possible involvement and creation of start-ups to ensure that new ideas, project, solutions specifically rail related would find an opportunity to connect with the sector and explore the possibilities to scale-up.

Last, but not least, the Programme should embrace on one side large scale demonstration activities, also in the form of piloting successful results obtained in the previous R&I Programme, and at the same time ensure a system (of systems) coordination of deployments funds available through CEF and other instruments.

2.3 Governance

❖ **Overall principles**

The current S2R JU partnership has suffered from an extremely rigid regulatory framework as established in its basic acts, with redundant provisions, rigid membership split, definition of rigid programme management governance, limits to enter the membership that did not foster inclusiveness, etc. At the same time, such a rigid framework has been essential and critical in achieving the progress reached by the S2R Programme, setting the basis for a rule-based collaboration that paved the way to a trust based collaboration currently governing the partnership.

In this respect, the new Rail R&I Partnership will benefit from the lessons learned in the past 4 years; in particular, the basic act should reflect key principles and ensure:

- Clear distinction of competences of all partners representing their strengths, to ensure the most appropriate delivery oriented approach and propose attractive ways to join the R&I work in the two Pillars;
- Transparent, simplified governance structure: simple regulatory framework, to give the Governing Board the possibility to clarify the approach for programme implementation;
- Emphasize commitment over representation: incentivize the weight of SMEs and start-ups from across Europe;
- An effective and efficient decision-making process towards delivering an ambition Programme and,
- To take on board the programme members with a key role in defining the specifications and requirements of future rail systems, including urban, such as operators and rail infrastructure managers.

The following governing bodies/ functions are proposed and seen as necessary to achieve the objectives of the partnership:

❖ **Governance**

The governance should be built around the following bodies:

- General Assembly
- Governing Board
- Executive Director
- Consultative/Advisory Bodies such as SRG and SC

In addition, with particular regard to the **System Pillar** needs and objectives, a System Pillar Steering Body is established.

❖ The **General Assembly** will be a deliberative body, which will consist of all categories of members, i.e. Core Members and Programme Members. Thus, it will guarantee the involvement, transparency, and contribution of all categories of members to the overall decision-making process, providing strategic input to the main orientations of the European Partnership. Its main role will be to endorse the progress of the Programme and highlight any need for future changes for consideration by the Governing Board, as follows:

- To discuss the progress of the Programme and provide indications for improvements to the Governing Board;
- To highlight any need for relevant future changes and provide indications to the Governing Board;
- To discuss European Partnership relevant documents agreed by the Governing Board on a proposal by the Executive Director, to endorse them or provide indications for improvements.

As for its functioning, the General Assembly should:

- Hold ordinary meetings once per year and, if necessary, be able to convene extraordinary meetings.
- Be organised in such a way that it allows broader participation and inputs by all Members.
- Take decision primarily by consensus. In case the General Assembly cannot reach consensus, the basic act will foresee the most effective voting system to ensure representativeness.

The General Assembly should be empowered to address its conclusions in the form of recommendations to be addressed by the Governing Board and receive due reporting of the follow up given later on.

❖ **Governing Board** – it should focus on strategic and operational aspects beyond the administrative and financial matters. The Governing Board is the key decision making body of the new Rail R&I Partnership, supported in its action by the chief executive officer of the organization.

Composition:

- European Union
- Core Members
- Executive Director
- Observers
    - ERA
    - ERRAC
    - Chair of the SRG Chair of the Scientific Committee

- Chair of the Users Committee

The functions of the Governing Board should be similar to the ones provided for in the S2R JU, although a stronger accountability of the Core Members in reporting on the activities they are involved with in the Programme should enhance the operational and strategic discussions of the Governing Board.

❖ **Chief Executive Officer –** he/she should perform the functions already established in the current S2R JU Regulation and consideration to be given to delegate additional administrative functions to have a more strategic role for the GB. Based on the experience of the current S2R JU, the Chief Executive Officer is to be supported by a Programme Board that will follow, steer and monitor the implementation of the Programme and the projects to ensure its consistency and integrity under the responsibility of the ED.

The Chief Executive Officer will be responsible for the Programme design, supervision and implementation, as already in the current S2R Regulation.

❖ **Advisory bodies**

- **Member States:**

Following an exchange of view with the S2R' States Representatives Group, the Member States consider important to maintain an advisory body, possibly enhancing its role in the decision making process and contributing to the agile definition of the Programme content, within the overall governance of the new Rail R&I Partnership. In this respect, the Member States' representatives indicated the need to:

- Reinforce the role of the Member States in the governance of the new Rail R&I Partnership to contribute defining priorities and better align national R&I and promote calls and results,
- Share information in the MS with representatives responsible for issues on R&I (e. g. to identify and promote common goals like multimodal mobility),
- Organize regular thematic workshops for MS for direct exchange of views and their needs as well as the customers' needs,
- Stronger and earlier involvement in the decision making processes,
- Link national rail industry with S2R activities for fast implementation (demonstrations, tests),
- Link R&I activities with national and regional railway undertakings, infrastructure managers and urban transport operators for fast implementation and fast environmental benefits, as well as national authorities.
- Linking partnership activities with national railway authorities for fast implementation and fast environmental benefits.

It will be important to add the need to avoid duplication at national and European levels and create more synergies (including with Horizon Europe work programmes addressing mobility). The convergence of rail national programmes to the new Rail European Partnership R&I Programme should be ensured since the beginning, notably via the Member State advisory body.

Nevertheless, the approach expected will go beyond the new Rail European Partnership, but it will concern all similar organizations.

It will be upon the Member States to formulate their views on their participation within the new Rail European Partnership.

- **Scientific Committee:**

A Scientific committee bringing together academics/research centres will contribute to the definition of all research and innovations actions as well as the progress of the overall Programme activities providing input to the ED/GB. Academia, Research, and Technology Organizations should advise on research and innovation actions with their knowledge. The SC has a large potential to contribute to the new Rail European Partnership and that the SC members possess valuable expertise in this respect, which will be exploited at its full potential. As per the Member States it should be able to provide agile advice in the shaping of the next Strategic Research Agenda of the new Rail R&I European Partnership.

❖ **System Pillar Steering Body**

The initial focus of the System Pillar will be on Command Control Signalling (CCS) and, subject to the necessary resources; it is expected to evolve to cover the rail system at large and as needed. In this respect, to achieve a coordinated and efficient process to deliver the European CCS, the governance proposed must:

- Be based on a clear mandate from the European Commission, in conjunction with ERA,
- Be such that the users are effectively represented and have a voice in decisions taken,
- Guarantee that decisions are taken based on principles of objectivity, impartiality and non-discrimination and substantiated according to these principles, to the benefit of EU railway clients and suppliers.

In order to provide the necessary inclusiveness and breadth of approach, the Steering Body shall be Chaired by the Commission and include sector representative organisations and technical bodies, ERA and the ED. Other persons (such as the ERTMS coordinator) may be invited to participate in meetings as observers.

The decisions in the Steering Group shall be made by consensus. If a consensus cannot be reached, then the representatives of the Commission, the Partnership and ERA shall assess the situation and decide on the way forward, after having listened all the different positions.

The Steering Group shall be responsible among others for:

- Setting the objectives for the System Pillar and monitoring delivery;
- Bringing the whole sector to develop the operational concepts, functional system architecture, and associated specifications and input to European standards, including consolidating and coordinating the diverse national / multi-national ongoing initiatives;
- Ensuring that the approach to operational harmonisation and the development of system architecture is adequately reflected in the Master Plan and its updates and, via the Chair, make proposals in this respect to the Governing Board;
- Establishing the detailed annual implementation plan for the System Pillar in line with the annual work plans adopted by the GB, on a proposal from the ED;

- Setting working groups where appropriate.

❖ **Users Committee**

A User committee is the voice of all potential users of the outcomes of this European Partnership. It brings together, represented by relevant Sectorial Associations, the different users' categories of rail sector (e.g., passengers, industry, infrastructure managers, railway undertakings, urban rail, mainline and high-speed, etc.). It contributes to the definition of the needs and expectations

of each type of the stakeholder, follow the project developments and help assessing the projects' results in order to foster user acceptance of developed solutions.

This is particularly relevant to address the fragmented market of local public transport stakeholders. Here Sectorial Associations plays a key role in developing the consensus between relevant local public transport actors, in order to achieve multimodal integration (which require involvement of local authorities) and door-to-door mobility (which has to consider other stakeholders rather than only Rail ones, and the Rail-Road mixed scenario - for Tram and Light Rail in particular).

The case for establishing a limited number of additional committees is also under consideration to foster inclusiveness and buying-in, for example for Transport Service Providers or other groups of stakeholders, as well as to provide independent assurance. Nevertheless, this should not increase governance complexity or unbalance.

❖ **Involvement of European Union Institutions and bodies**

The proposed Rail European Partnership will provide the opportunity for a strong policy steering by the parent DGs, DG MOVE and R&I, to ensure that railway research and innovation, on the one hand, allows for an encompassing participation at low TRLs level to foster fundamental research and blue-sky research. On the other hand, would ensure that higher TRLs result in innovative solutions targeting a major system transformation having clear impact on future standards and regulatory framework. The Union, represented by the Commission, has a leading role and ensure the alignment of the R&I agenda with Union policies, e.g. industrial and competitiveness, climate, environment, digital, social, etc.

The (institutionalized) partnership is consequently part of an overall system under the responsibility of DG MOVE and R&I that includes policy developments, research and innovation activities, regulatory implementation and framework, monitoring and supervision, with a cycle approach towards the achievement of integrated mobility for citizens and freight.

The Rail European Partnership will report regularly to the Member States and the European Parliament at their own request and in coordination with the European Commission. The Annual Discharge procedure will be the occasion to ensure a regular reporting.

The role of ERA is also paramount: the Agency will provide its needs in terms of R&I activities to the new Rail Partnership; the ED will submit them to the GB as part of the AWP process after having duly assessed them. In addition, the role of ERA will be essential in anticipating the needs for changes to standards or regulatory framework to foster the market uptake of innovative solutions within the SERA.

The Rail Partnership will build upon existing networks of national authorities together with ERA to ensure that no administrative barriers are present for the market uptake of the R&I results.

2.4 Openness and transparency

❖ **Inclusiveness without governance dilution**

The broad involvement and the common vision represent one of the greatest strengths supporting the establishment of the Rail European Partnership. The vision brings together the perspectives of different segments of the European Rail System, offering an opportunity to develop an outstanding level of diversified expertise from the stakeholders involved – fully aligned with the EU policy goals.

The Rail European Partnership is therefore structured around a common, publicly accessible Programme that provides full transparency regarding its planning & its activities. The balance between the ownership by, and commitment, from the partners, and the opportunity to a wide range of stakeholders to contribute/access Programme, will be at the core.

For R&I efforts meaningfully to support new technologies that also enable geographical and technical integration of rail systems, it requires the full value chain of such systems requires integration, ensuring a coherent approach from design to the funding of the deployment. It will also face the reality of uneven conditions in different national networks, where there may be significant disparities in the competences of the rail industry or scientific community, etc.

As described in the previous sections, the proposed European Partnership will be represented by a strong nucleus of Core Members – with a balanced participation of key stakeholder groups – and a wide range of entities – based on the current experience of Shift2Rail estimated at 400+, all together representing the rail sector value chain and beyond.

Concretely openness will be reached by attracting and providing wide opportunity of participation to entities that will be ready to commit to a shared programme, contributing with their expertise and breakthrough technologies. It requires providing the Rail R&I Partnership with the necessary funding as well as a regulatory framework that does not create bureaucracy but opportunity for investments.

It will be structured around the need to bring forward an ambitious SRIA while ensuring the necessary inclusiveness, stakeholder representativeness, geographical balance and international dimension, inter alia towards a strong sustainable and competitive European Rail industry,

***Membership policy**:*

Beyond the Core Members that are expected to be listed in the annexe of the European Partnership establishing Regulation, it has already been indicated that the other Associate Programme Members will result from the entities to which the research and innovation multi-annual activities will be awarded, so that they can commit to specific parts of the Programme, bringing specific expertise and a commitment per content/activities, possibly linked to specific phase(s) of the Programme. The relevant Call for Proposals and/or Call for Tenders will clearly indicate the expected outcome; such approach will ensure an inclusive participation without creating artificial boundaries of collaboration.

Development of the Strategic Research and Innovation Agenda

The proposed Rail Partnership will ensure an authentic dialogue on R&I in a transparent way taking into account the interests of the final users, the European citizens, as well as of all stakeholders involved. In this respect, ERRAC is the best placed organization to bring together the sector, the representatives of the Member States and scientific community, ERA, etc. to deliver a long term R&I agenda that will input the European Rail Master Plan for R&I. In the next months, and via the meetings already planned, ERRAC will ensure the necessary consultation process in a transparent manner.

In order to ensure an inclusive participation, this High Level Paper and its annexe with a detailed description of the possible research and innovation areas, result from the joint work of European Rail Associations, ERRAC, and the support of technical bodies. It has been presented in different public events and comments were collected all along its preparations.

Multi-Annual Work Plan, Annual Work Plans and Calls

To ensure openness and transparency in the course of implementation of the activities, the Master Plan will be translated in a Multi-Annual Work Plan that will be refined considering the evolution of the needs of the users and Union's policies, with the additional support and input of the States Representatives Group and the Scientific Committee. In addition, the proposed System Pillar will be an additional element to ensure the alignment of the overall activities to the evolving needs of the different actors of the rail system, including ERA and national authorities.

Participation in the calls for tenders or proposals will be ensured in a fair and non-discriminatory way to all potential beneficiaries, while recognizing the long term commitment of the Core Members.

The new Rail European Partnership will ensure the necessary information process to attract new potential beneficiaries, providing them with detailed information on the functioning of its activities.

Moreover, the new Rail R&I Partnership will be the tool bringing together different instruments, establishing MoUs with European regions, building upon the actions started in S2R with regard to Regional and Cohesion Fund, connecting with CEF and ERTMS Deployment Action Plan can create the foundations of a European integrated network. Dedicated outreach activities will be organized to attract under-represented Member States.

The yearly budgetary cycle and the establishment of Annual Work Plans will be via a transparent process building upon the input of the Multi Annual Work Plan, the Master Plan, the updated input of the Core Members, including the European Union, and Associates, the input and revision of the States Representatives Group and Scientific Committee, ERA and taking into consideration the progress of the work of the System Pillar. This process has been in place for the last 4 years in the S2R JU and would benefit from more permeability to the change that currently offered by the mechanism underpinning the current partnership,

To ensure the necessary participation to the Calls, the Partnership will have information days, virtual or physical, at European, National and regional level, building upon the presence of its Members in different Member States and future Associated Countries to HE.

It is fundamental to recognize that "one model fits all" approach does not always constitute the basis of attractiveness of potential beneficiaries, as it does not answer the needs of participation from specific sectors.

Any mechanism and provision underpinning the Partnership should be set up with a clear objective of avoid disincentivising actors from engaging with the Partnership (e.g. by placing unreasonable financial burden on them compared to other forms of participation, asking for a long term commitment and not recognizing it, etc.).

Flexibility should be kept in the definition of the projects. To cope with the development of new requirements or technologies yet to emerge, but that could impact rail transport in the future, it is important not to define all the detailed technical Programme of the future during the preparation phase. There must be capacity to engage the sector in adaptation and adjustment of the Programme should a revision of the work programme be needed.

In accordance with the Financial Rules and other relevant provision, the Partnership will prepare and publish yearly annual reports which will include, inter alia information on the level of participation in the programme, results achieved and expected impact, KPIs reporting and any other information

relevant to demonstrate the commitment of its Members and management towards a mission oriented Programme.

The transparency of the multi-annual and annual programming cycle, which is concluded yearly with the necessary reporting mechanisms, will be also ensured via the set up of the proposed General Assembly which will bring together once a year all the new European Partneship's community.

Finally, the discharge process of the European Parliament and Council, the independence assurance provided by the European Court of Auditors and the Internal Auditor of the Partnership, will be paramount to create trust on the sound management of the organization in achieving its objectives.

Transparency of the rules

The rules of procedure of the bodies of the Partnership will be made publicly available, the minutes of the meetings and any other relevant documents will be made publicly available in accordance with the Partnership's regulatory framework.

Dissemination and communication

The effect of the Partnership's result shall be made visible via a consolidated and structured approach to dissemination and communication. In this respect, the resources for such activities shall be consolidated at Partnership level to maximize their impact instead of at project level, where mostly they are used for the expert community around the project itself. Initiatives & tools such as the Partnership's websites, scientific publications, annual activity reports, social media and organization of bespoke events and workshops will ensure the non-discriminatory access to information about the Rail European Partnership initiative and the efficient dissemination of projects results of the partnership throughout the whole lifetime and beyond. In this respect, it will be essential to ensure the centralized management of such activities by the European Partnership to ensure a major leverage effect, together with the members.

In this respect, also building upon the role of European associations, such as UNIFE, EIM, CER, EUG EULYNX, and UITP, EURNEX, UIC, UIP, ERFA, etc. will facilitate the buying in process, the dissemination and deployment of results by the stakeholders; this should include by acknowledging their specific competences and securing dedicated European funding instruments.

Annex: Transforming Projects Description

Transforming Project n°1: Assets for Automatic & Autonomous Operation

Today automatic operation in metros and people movers is a reality. Experience has demonstrated enormous benefits where automatic train operation (ATO) is in place, like increased capacity, punctuality and flexibility, or reduced energy consumption and maintenance and operating costs, among other. Such benefits should also be provided by more automated and autonomous operations in other rail transport segments, such as regional and suburban trains, high-speed trains, freight trains or light rail vehicles (LRV) and tramways as well as including automated train preparation/train composition. This also implicitly means that legacy systems (i.e. comprehensive network until 2050, segregated, suburban and local networks) will have to support automation to unblock the deployment of ATO and a seamless automatic/autonomous operation along Europe, also interfacing other autonomous transport modes, such as cars, pods, buses or even drones.

Shift2Rail progressed significantly in that direction, showcasing GoA4 operation over ETCS. However, a complete automatic corridor line (GoA4) with mixed traffic still has to be deployed and operated to fully get the benefits and learn about difficulties, providing answers relative to the operational constraints, the possible performances, and the way to work in degraded conditions. Then the migration of the whole network has to be tackled by increasing the autonomy of vehicles and implementing new onboard functions to overcome the limitations of legacy systems. Obviously, a special case is tramways and other vehicles on local segregated lines with no underlying signalling system or with a very basic one, where a big effort on artificial sensing and other similar computing techniques has to be done to make them safe, affordable and certifiable. Cooperation with Road ITS research programmes is an important part of delivering autonomous tram operations in mixed traffic. Making rail vehicles more autonomous and monetising Shift2Rail's concepts, such as the definition of the virtual coupling, have to lead to the development of new lightweight train protection systems based on vehicle mutual supervision.

In order to achieve a quick market uptake for GoA4, proposed solutions will have to be open and interface standardised, simple, affordable and safe. The analysis of the needs and requirements have to reflect each rail market segment needs (mainline interoperable, suburban non-interoperable, metro, LRT/tram). Solutions also will have to be modular and evolvable to allow progressive deployments, minimising the investment risk and ensuring upgradeability and component interchangeability. Beyond the technical challenges, other important aspects, such as social acceptance or incorporating skilled staff on the new technologies, have to be also faced by this Transforming Project. Finally, the definition of a new set of operational rules is required to enable an European wide deployment of automatic and autonomous[28] rail operation.

Doubtless, automation and autonomy of rail assets directly and significantly contribute to at least two of the European Commission's priorities for the period 2019-2024: The European Green Deal (fighting climate change) and the Europe fit for the digital age (digital technologies including artificial intelligence). A digital world will not accept today's railways, so changes

[28] Automation operation is characterized by performing sequences of tasks based on pre-defined rules and on received information (with or without a driver). Autonomous operation is characterized by the capacity of a vehicle to respect its environment in such way that it can make intelligent decisions based on the circumstances.

are required. Automatic and autonomous train operations will bring clear benefits in terms of system capacity, sustainability and

economic savings. Indeed, reduced and optimised energy consumption, reduced operational costs, enhanced punctuality and, in particular, much higher system resilience will be the major impacts of these technologies. An affordable and predictable rail system will increase its competitiveness as mode of transport. Moreover, such predictability will pave the way for new approaches in terms of optimised energy management at system level, which together with the implicit reduced energy consumption, will contribute to the European Commission's Green Deal in a significant manner. Achieving autonomy for urban and suburban open air rail vehicles, fully connected to the transport ecosystem, is a required cornerstone to achieve the Smart Cities policy of the European Commission, as part of the Europe fit for the digital age priority.

Transforming Project n°2: Railways Digital Twin, Simulation & Virtualisation

This approach of digital twin is currently being developed in different industrial fields mostly in manufacturing industry for concentrated assets, where it basically combines visualization of an asset or a system behavior under operation along with simulation of its performance and expected life in order to better operate the system and anticipate potential failures. The "Railway Digital Twin" built and demonstrated at system and subsystem level will be applied to several areas with high impact to business performance, such as:

- Management of assets during their whole life, with particular focus on interactions across the complete railway system;
- Increased reliability, availability of assets and optimisation of their design;
- Real-time and future oriented prediction of operational aspects;
- Reduction of lead-time and cost for design: design based on performance verification rather than specification, and improved models for virtual validation and certification.

The development of Digital Twins (both at system or subsystem level) requires a holistic approach that relies on the following pillars, which will be developed in cooperation with the other Transforming Projects as services in a coordinated architecture:

- Visualize: The Digital twin will present to various stakeholders in a comprehensive, adapted views , different views of the current state of the system (rolling stock, infrastructure) as well as its usage intensity along with its history (past services , history and contents of maintenance operations)...
- Simulate: Digital twins require mathematical models that allow to mimic the real behaviour of systems / subsystems. These models will physical/analytical laws, and new tools based on Machine Learning/Artificial Intelligence, expert knowledge, …. The use of advanced computational techniques will be required in order to obtain quasi real time solutions.
- Predict: Digital twin should have prediction capabilities coming from the combination of simulation models fed by operational inputs. Decision helping systems will also be of use to develop operational scenarios both for planning maintenance and later for operation recovery in case of an incident.

The Digital Twin will have direct impact on the costs and efficiency of the rail industry both at design stage (with verified performances vs specification design) and operation and maintenance (through real predictive maintenance). It will furthermore pave the way to full connectivity of the rail:

1. Digital systems interoperability will foster the use of general industrial products and services for integration in the railway system at SERA context, and the application of such interoperability approach for urban rail will be analyzed and evaluated.
2. Service interoperability will foster connectivity between land transport modes for safety and customer centricity, ensuring comfortable connections between trains, metros, trams, busses, taxi services; freight delivery chains using trains as a backbone; Data applications using environmental and railway system data for optimizing railway applications as well as external applications.
3. Last but not least it will foster the development of railway oriented Multiphysics simulation tools as well as real time algorithms for system behavior prediction.

Transforming Project n°3: Smart Asset Management

This Transforming Project will leverage on the integrated system provided by Shift2Rail to complete the leap to smart and prescriptive asset management, by transforming the decision support system in an advanced autonomous operation and maintenance framework for railway infrastructure.

This goal will be achieved by developing the following Building Blocks:

- Advanced solutions for prognosis and health assessment at system level;
- Maintenance solutions supported by digitalization of asset during the lifecycle;
- Advanced Decision Support Systems (DSS) for holistic management, integration and cooperation;
- Development of specific & enhanced technologies for maintenance execution;
- Development of demands and verified regulations for design and renewal of assets enabling cost effective maintenance.

The overall objective of this transforming Project is to implement holistic Asset Management, working across assets, intervention types and functional boundaries to further increase the capabilities of the system developed in Shift2Rail, to reduce downtime for infrastructure, systems and rolling stock, to utilize capacity and reduce costs.

This Transforming Project will be the enabler for prescriptive and automated maintenance, which will be simple, fast, integrated and cost-effective. Equipment health will be constantly self-checked, diagnosed and cured by performing maintenance tasks at the right time with the right method.

The main foreseen outputs are the following:

- Standardization of critical aspects of the digital system (such as interfaces, protocols, communications, data structures) necessary in order to be able to integrate the different subsystems of e.g. infrastructure and rolling stock for improving interoperability;
- Set-up of an open framework that allows fruitful use of data and information by different stakeholders involved in operation and maintenance;
- Release of new asset management concept based on advanced analytics with the aim of automating rail assets monitoring and diagnostic systems;
- Design and implementation of robotic solutions for automatic execution of maintenance and management policies;
- Adoption of Automation of Maintenance in procedures, rules and EU/National regulations;
- Fostering the integration between the design principles of future railway systems and the effective management of legacy products.

This Transforming Project will result in increased and enhanced operational flexibility and will contribute to greater robustness, resilience, and reliability of service as well as faster recovery from service disruption, along with a reduction of LCC and contribute to address the challenges of climate change. Reduced persons will be in field, as robots will perform hazardous work, with limited disruption of railway service. Higher quality will be achieved and significant emerging problems will be avoided.

Transforming Project n°4: Smart Integration for Door to Door (D2D) Mobility

Aiming at the integration of the rail in the European mobility ecosystem, this Transforming Project will propose end-users a seamless access to all services associated to their multi-modal journey, and the advanced integration with other modes of transport and freight growing demand. Supported in data analytics and advanced AI, it will allow real time information to the users on any modification or disruption, complemented with the relevant context data or way forward. Improvement of the interfaces with the other modes, with a special focus on accessibility issues, in particular with regards to stations and multimodal hubs, by matching accurately mobility demand to available supply, taking into account the characteristics of each mode allowing the development of a flexible transport service tailored on people's needs and capable to adapt promptly to the demand, assuring at the same time the GDPR legislation or the necessary resilience to Cyber.

This Transforming Project will address the following challenges:

- Provide the connection between the two territorial scales and the different services. To achieve these connections properly, harmonization of relevant specifications is essential, and building a process to set up a "commonly agreed" language at EU level – in terms of ontologies building up on TRANSMODEL together with an identification of the various clusters of customers and trip purposes to be served at the local and/or EU D2D scale.
- Provide the best multi-modal offer according to individual need: This includes a shared and unified transport token, distributed general ledger and automatic contract execution, service bundle self-configuration, inclusive multi-modal journeys for people with reduced mobility, an end-customer data sharing framework, passenger's information in multimodal hubs and personalized and tailored flexible transport services built around mass public transport with rail as backbone.
- Improve operations for a controlled multimodal transport offering: This includes the enhancing of the physical and digital integration of rail in a multi-modal offer, using artificial Intelligence for green D2D transport, making use of multimodal traffic event management, dealing with security/cybersecurity and increasing the delivery of climate neutral travels.

The following main topics and activities shall be improved, enriched or developed:

- Organisation of proper bottom-up voluntary harmonisation of specifications, based on TRANSMODEL and its developments with the support of the MMTIS regulation and ITS Directive
- Customer experience application, to enhance the Shift2Rail Travel Companion to be more compliant with GDPR rules and enhancement of Trip Tracker with GPS/Galileo and sensor based personal tracking.
- Multimodal travel services, enhancing the One-stop-shop to include more TSP's & new modes;
- Improved TMS and multimodal planning, focusing on Multimodal Traffic Event Management to adapt rail traffic to the actual demand to react and adjust the complexity of traffic dynamics.
- Multi-modal Cyber-Security, leveraging on cyber security & GDPR compliance with a well-defined regulatory framework on data sharing and ownership.
- Multi-modal freight services, through an integrated approach and optimization of the passenger service along with the increase of capacity of freight service offer

(especially for the first and last miles), without impact on the quality of the service provided to travellers.

- Physical integration of the rail, including improved accessibility & connection with other modes.
- The creation a Meta-standard to translate Shift2Rail developments into a norm.
- Real time forecast of the transport demand, to allow the fusion and processing of the information provided by multiple sensors to improve the service offer.

The deployment of an integrated inter-modality and MaaS platforms could be enabled by:

- Integration hub for mobility providers, to elaborate a decentralized sharing model based in the form of communities, instead of requiring that any provider complies with a common interface.
- Provide a licensing framework for multi-modal platforms, so that a licensing agreement shall be put in place and be supported by a global framework.
- Create a shared universal transport account, to which the travellers could subscribe in order to travel on any network.

Transforming Project n°5: M.O.D. Systems for Pods

Todays' travelling from door-to-door is challenging and stressful. Overcrowded at any transportation mode: in the air, on the road and on rail tracks. Key requirement of end users for passenger and cargo is easy, convenient and affordable in-time door-to-door transportation day or night. A disruptive way to reach these requirements: Not the passenger or the freight is interchanging but will be interchanged in a personalized transportation box in an intermodal travel environment.

The M.O.D. System will be standardised, scalable and suitable for all transportation modes, according to the actual needs of the end users and the suistainable traffic situation and operations in the different modes an optimized routing will be calculated and executed.

The Vision of the project is to develop a rail based fully automated Multi-Modal Mobility-System for passengers and goods with three key elements:

- ***Moving Infrastructure*** – intermodally connected by "Pods"
- ***Open Platform*** – based on common standards and standardised interfaces
- ***Disruptive Operation Models*** – for existing infrastructure

This Transforming Project will address a Game Changer for Railway Transport and other transport modes. The challenge will be to change the transport offer of public transport from a mixture of individual and public transport to a collaborating public transport system (within a context of sharing economy) under the aspect of high sustainability and environmental friendliness. Strengthen the railway position in the future mobility market on basis of cutting-edge technology for automatization, digitalisation and electrification.

<u>This Transforming Project will:</u>

- Support the seamless door-to-door mobility paradigm and attract citizens to the public transport system with individual user experience.
- Redefine aspects of services to mobility on demand, last mile and to flexibility for not mainstream transport solutions (PRM, combination passengers & goods).
- Optimise the usage of all infrastructure with minimum energy consumption and environmental burden, no more or less parking cars.
- Increase the efficiency and flexibility of the system: always moving devices, none or little waiting time, standardised open platform with pod carriers for each transportation mode.
- Contribute to cleaner and more balanced transport options according to the policies, legislation and initiatives of EU with the main objective of decarbonising transport that is a major challenge for EU citizens.

Transforming Project n°6: Environmentally Friendly and Attractive Sustainable Mobility

The railway has unique assets, which will enable it to mitigate the effects of climate change and to remain the cleanest mode of transport. It can lead decarbonisation in mobility and provide sustainable and attractive transportation for passengers and freight being also resilient to climate crises and resources depletions. The sector can have a positive effect on the climate by reducing energy consumption, emissions and by decarbonisation, and on health and environment by reducing noise and vibration, particle emissions, water consumption, bio-diversity impact and selective use of materials.. Within this TP all necessary aspects of environmentally friendly and attractive sustainable mobility will be considered, including e.g .infrastructure for hydrogen trains as well as hydrogen trains themselves.

This Transforming Project will focus on:

1) Attractive Environmentally Friendly Mobility
   a) Increased attractiveness and capacity by improved flow with comfortable, reliable and safe services using simulation tools and new technologies for the stations, interfaces and vehicles. Low energy and low emission on board comfort and entertainment/attractive services.
   b) Consumption of Raw Materials: Standardised designs, integrated functionality, improved reparability and maintainability, and use of software to reduce the consumption of raw materials through reduced use of components.
   c) Environmental Footprint Tools & Circular Economy: Development and use of materials including recycled, renewable and bio-degradable materials. Understanding the risks linked to the use of critical raw materials for products and spares. Develop additive manufacturing for railways with special regard to railways´ specific requirements. Development of certification of environmental impacts.
   d) Noise, Vibration and Air Quality: Simulation tools and new technologies to reduce internal and external noise and vibration emissions of the complete system in all environments. Development of braking systems with reduced environmental impacts.
2) Energy Efficiency (System Development)
   a) Holistic Energy Management: Defined requirements and developments for the complete railway in different operational environments and energy management, energy recovery and smart infrastructure. Holistic energy management where vehicles and the infrastructure know their status and operational profile and forecast and optimise energy consumption and regeneration. Developed wayside refilling, recharging and energy storage infrastructure Upgraded current infrastructure using new technology for AC/DC power electronics.
   b) System Development: Optimised energy management within vehicles and compulsory use of energy saving technologies. Development of running gear new and optimised transmission and modular components, and environmentally sustainable air conditioning.

3) Traction and On-Board Energy Storage Systems

   a) Management strategies for different train architectures and integration of the next generation control-command architecture.
   b) Next generation propulsion technology and energy storage elements to enable decarbonised powered vehicles for new build and retrofit.
   c) Integrated model-based design methodology enabling improved simulations and realistic test environments.

4) Healthy mobility and available systems

a) Vulnerability of railway transport system against pandemic or “polluting” event situations. Deeply characterising each event and its consequences on the systems
b) Healthy and sanitary solutions by developing necessary mitigation actions with a modular /plug&play approach. Defining requirements and developing solutions. For instancen, high level air filtering/purification, as well as “interiors dynamic-continuous cleaning” and/or “self-disinfecting materials” will become a key factor for the passenger health protection.

There will be a positive effect on the environment by more use of the rail system and reducing its impact. The railway will be managed holistically for the efficient use of energy and systems will be designed to reduce energy use, emissions and use sustainable materials. Tools, processes, interfaces and regulations will be standardized which will improve efficiency.

Transforming Project n°7: Rail Freight – The backbone of a green logistic chain

The full integration of rail freight in the multimodal logistic chain ensures green, sustainable door to door logistics services. Electronic customer portals, digitized and automated operations, intelligent freight wagons and freight trains as well as multi modal hubs will be the key performance driver for increasing productivity, capacity, reliability and profitability of the rail freight system. The R&I developments to digitize and automate the rail freight system will pave the way to increase the modal split share in European transport market up 30 % in 2030 and beyond in the following decade. Economical growth in Europe will not further suffer under increasing pollutions and congestions of the transport sector.

Boosting competitiveness, performance, reliability and profitability are the key challenges for rail freight to provide marketable services for the European economy and society. The integration into the multimodal logistic chain has to be achieved through a consequent transformation to an automated and digitized rail freight system. The customer demand has to be linked with the logistic service supply. Energy and decarbonisation challenges must be tackled to make the rail the most eco-friendly transport means by 2030.

Shift2Rail lays the foundation to start the transformation process to a digitized and automated rail freight system. The Shift2Rail Innovation Programme 5 is focusing on Automatic Train Operation (ATO) for freight, new propulsion concepts, on new freight wagon designs and on improved yard management.

This Transforming Project will focus on:

- Digitized customer interfaces providing real-time information and data exchange on various state of the art communication channels.
- Automated freight train operations based on GoA4 (fully automated) linked with a new generation of railway assets tailored to automation.
- The multimodal integration being based on the development of federated network of platforms that will be the centre part of the integration of rail freight into a multi modal logistic chain.
- Automated train preparation and train composition, yard and terminal handling (shunting and marshalling; automated container handling, fully automated digital coupler).
- Energy efficient propulsion combined with electrification of freight wagons and energy autonomy for last mile and shunting operations

The increase of the rail freight modal split share up to 30 % will cause a significant environmental impact 2019 – 2030*: More than~ 290 Mio. tons CO2 will be saved,~ 40,000 premature deaths due to pollution avoided and ~ 5,000 fatalities due to truck accidents are saved.*Source: UNFCCC, UIC Handbook, OECD

The performance of the rail freight system will increase significantly:

- Reduction in noise emission by 30%, of energy consumption by 20%, of operational costs : 40 %
- Increased reliability up to 98%, capacity 40 % and productivity 40%.

Transforming Project n°8: Network management Planning and Control

Infrastructure managers (IMs) needs to improve current process together with Railway Undertakings (RUs), Railway industry and other stakeholders. Digitalisation and shared data are enablers for automation and help to solve complex capacity problems with many involved actors. The vision is to have timetables and operational traffic that are connected, optimised, robust and punctual and still deliver high capacity utilization. The main scope is to develop the planning and control aspects of network management. The challenges are:

- To close the gap between timetables and operational traffic and develop methods in order to maximise capacity utilization and punctuality. Digitalisation will help IM and RU to be pro-active and raise quality of the system. Quality of the system needs to be followed and controlled.
- Improve planning and decision support for passenger and freight traffic, yards and maintenance and the coordination between these – to develop planning and operational processes, data sharing, micro simulation, macro simulation, optimisation and AI data analytics.
- Improved network management - automation, information sharing and modelling. Improved interaction between Ims, RUs and other stakeholders. To perform cross border simulations with many countries as well as national simulations with many organizations involved.
- To design and simulate the railway system of the future with new functionalities: To simulate ERTMS, C-DAS, ATO and real time information platforms for timetabling and operational traffic, to study effects and optimise capacity, punctuality and relevant KPIs.
- Mathematical optimisation of planning/scheduling of railways and simulation and decision support for handling of smaller and major disturbances in the operational traffic process.

This Transforming Project will perform realistic and relevant pilots and demonstrations and hand over research results for implementation. Main problem owner and data provider are Infrastructure Managers and Railway Undertakings (e.g. passenger data). Railway industry, maintenance contractor, Yard and station managers can also be data providers. Agile work in several steps will be set-up: (1) Define problems, best practice and vision; (2) define research need, use cases and demonstrator requirements; (3) perform research/demonstration

- Innovation/demonstration 1 – Controlled and optimised system punctuality by improved methods.
- Innovation/demonstration 2 - Improved planning and decision support for maintenance, passenger- and freight trains including nodes and yards.
- Innovation/demonstration 3 – Improved network management, simulation and data sharing.
- Innovation/demonstration 4 – Railway system of the future – ATO, ERTMS, Connected DAS.
- Innovation/demonstration 5 – Optimised timetables and operational decision support.

This Transforming Project will create:

- Higher capacity, higher punctuality and a more efficient railway system.
- More competitive, automated and punctual railway transports for passengers and freight.
- A sustainable and environmentally friendly transport system for passenger and freight.