European Commission

Impact Assessment Study for Institutionalised European Partnerships under Horizon Europe

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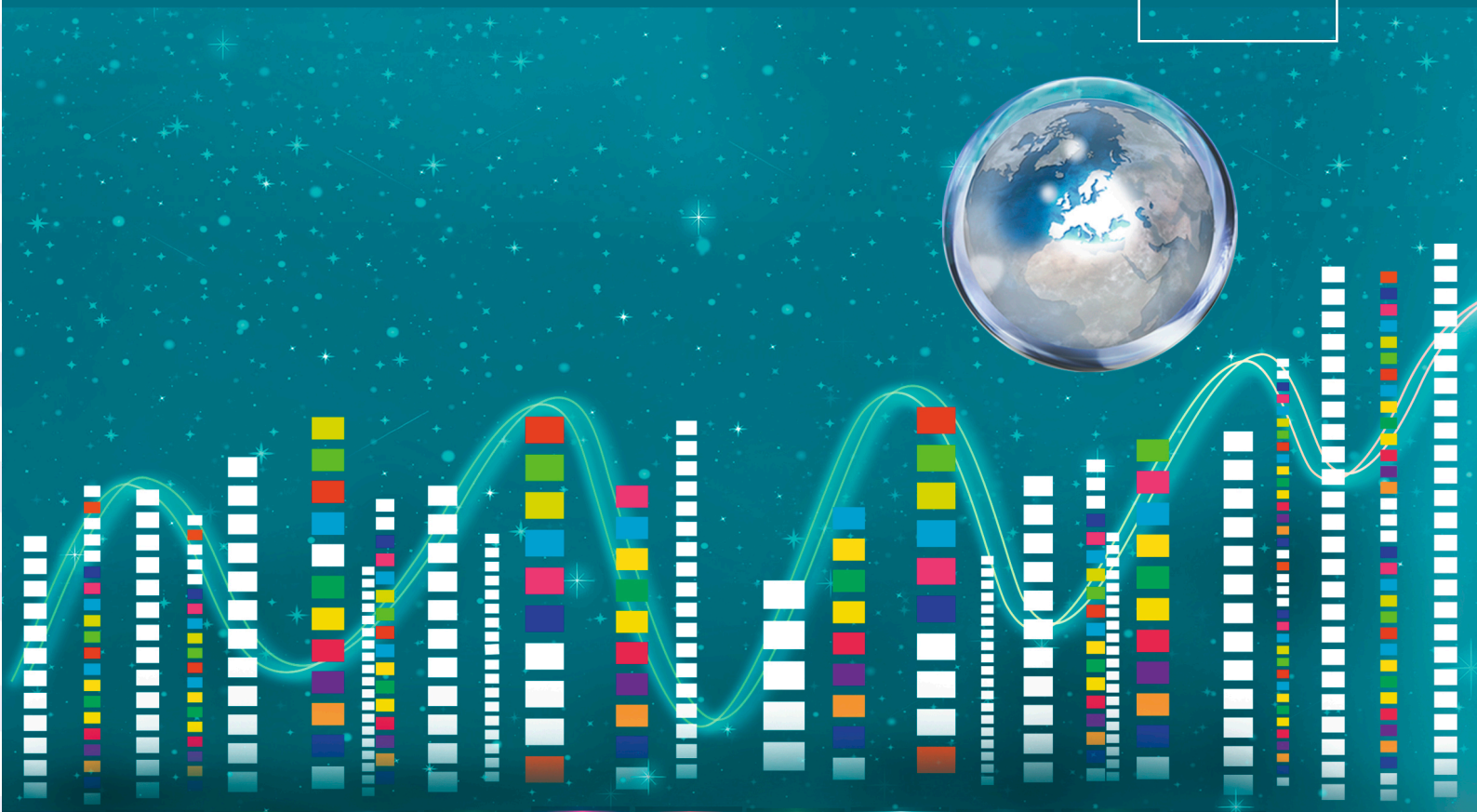
Report



Research and Innovation

Impact Assessment Study for Institutionalised European Partnerships under Horizon Europe

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EUROPEAN COMMISSION

Impact Assessment Study for Institutionalised European Partnerships under Horizon Europe

In collaboration with

2020 Directorate-General for Research and Innovation EN

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Introduction

This Impact Assessment Study had the primary objective to support and provide input to the impact assessments of the first set of 13 European Institutionalised Partnerships based on Articles 185 and 187 of the Treaty on the Functioning of the EU (TFEU) that are envisaged to be funded under the new Framework Programme for Research and Innovation, Horizon Europe.

In addition, the Impact Assessment Study team contributed to future European policymaking on the overall European Partnership landscape by means of a horizontal analysis of the coherence and efficiency in the implementation of European partnerships. The purpose of this analysis was to draw the lessons learned from the implementation of the impact assessment methodology developed for this study and to formulate recommendations for the refinement and operational design of the criteria for the selection, implementation, monitoring, evaluation and phasing-out for the three types of European Partnerships. Finally, an impact modelling exercise was conducted in order to estimate the potential for longer-term future impacts of the candidate Institutionalised European partnerships in the economic and environmental sustainability spheres.

Technopolis Group was responsible for the overall coordination of the 13 specific impact assessment studies, the development of the common methodological framework, and the delivery of the horizontal analysis. It also conducted specific analyses that were common to all studies, acting as a 'horizontal' team, in collaboration with CEPS, IPM, Nomisma, and Optimat Ltd. For the implementation of the individual impact assessment studies, Technopolis Group collaborated with organisations that are key experts in specific fields covered by the candidate Institutionalised European Partnerships. These partner organisations were Aecom, Idate, Steer, Think, and Trinomics. Cambridge Econometrics took charge of the impact modelling exercise.

The Impact Assessment Study was conducted between July 2019 and January 2020. The 13 Impact Assessment Studies were conducted simultaneously, based upon a common methodological framework in order to maximise consistency and efficiency. The meta-framework reflected the Better Regulation Guidelines and operationalised the selection criteria for European Partnerships set out in the Horizon Europe Regulation. The 'Horizontal analysis of efficiency and coherence of implementation' was conducted in the same time period, building upon the information available on the 44 envisaged European Partnerships landscape as in May 2019, complemented with information on five envisaged European Partnerships as decided by the European Commission in October and November 2019.

This final report contains the reports of all individual impact assessment studies and the 'horizontal' analyses. It is structured in two parts, reflecting the two strands of analysis:

PART I. Impact Assessment Studies for the Candidate Institutionalised European Partnerships

1. Overarching context to the impact assessment studies

This report sets out the overall policy context and methodological framework underlying the impact assessment studies for the candidate Institutionalised European Partnerships. It describes the changes in approach to the public-private and public-public partnerships under Horizon Europe compared to the previous EU Framework Programmes. An example is the requirement that all envisaged European Partnerships be implemented as either co-programmed, co-funded or institutionalised. The impact assessment studies will consider these three scenarios as the different options to be assessed, in compliance with the Better Regulation guidelines and against the functionalities that the candidate partnerships are expected to fulfil. The report describes the common methodological framework to assess the envisaged initiatives accordingly. The report also presents the landscape of European Partnerships at the level of Horizon Europe Pillar 2 clusters, which lay the grounds for all

of the impact assessment studies except the candidate Institutionalised European Partnership for Innovative SMEs.

2. EU-Africa Global Health Candidate Institutionalised European Partnership

This initiative focuses on research and innovation in the area of infectious diseases, with a particular focus on sub-Saharan Africa. It will address the challenges of a sustained high burden of infectious diseases in Africa, as well as the (re)emergence of infectious diseases worldwide. Its objectives will thus be to contribute to a reduction of the burden of infectious diseases in sub-Saharan Africa and to the control of (re)emerging infectious diseases globally. It will do so through investments in relevant research and innovation actions, as well as by supporting the further development of essential research capacity in Africa. The study concluded that an Institutionalised Partnership under Art. 187 of the TFEU is the preferred option for the implementation of this initiative.

3. Candidate Institutionalised European Partnership on Innovative Health

This initiative focuses on supporting innovation for health and care within the EU. It will address the EU-wide challenges raised by inefficient translation of scientific knowledge for use in health and care, insufficient innovative products reaching health and care services and threats to the competitiveness of the health industry. Its main objectives are to create an EU-wide health R&I ecosystem that facilitates translation of scientific knowledge into innovations; foster the development of safe, effective, patient-centred and cost-effective innovations that respond to strategic unmet public health needs currently not served by industry; and drive cross-sectoral health innovation for a globally competitive European health industry. The study concluded that an Institutionalised Partnership based on Article 187 of the Treaty on the Functioning of the EU (TFEU) is the preferred option for the implementation of this initiative.

4. Candidate Institutionalised European Partnership in High Performance Computing

The initiative focuses on coordinating efforts and resources in order to deploy a European HPC infrastructure together with a competitive innovation ecosystem in terms of technologies, applications, and skills. It will address the challenges raised by underinvestment, the lack of coordination between the EU and MS, fragmentation of instruments, technological dependency on non-EU suppliers, unmet scientific demand, and weaknesses in the endogenous HPC supply chain. The initiative has as its main objectives to enhance EU research in terms of HPC and related applications, continued support for the competitiveness EU HPC industry, and fostering digital autonomy in order to ensure long-term support for the European HPC ecosystem as a whole. The study concluded that an Institutionalised Partnership is the preferred option for the implementation of this initiative as it maximises benefits in comparison to the other available policy options.

5. Candidate Institutionalised European Partnership in Key Digital Technologies

This initiative focusses on enhancing the research, innovation and business value creation of European electronics value chains in key strategic market segments in a sustainable manner to achieve technological sovereignty and ultimately make European businesses and citizens best equipped for the digital age. It will address the risks of Europe losing the lead in critical industries and services and emerging KDTs. It will also tackle Europe's limited control over digital technologies that are critical for EU industry and citizens. It has as main objectives to strengthen KDTs which are critical for the competitive position of key European industries in the global markets, to establish European leadership in emerging technologies with high socioeconomic potential and to secure Europe's technological sovereignty to maintain a strong and globally competitive presence in KDTs. The study concluded that the Institutionalised Partnership is the preferred option for the implementation of this initiative.

6. Candidate Institutionalised European Partnership in Smart Networks and Services

This initiative focuses on the development of future networks infrastructure and the associated services. This includes bringing communication networks beyond 5G and toward 6G capabilities, but also the development of the Internet of Things and Edge Computing technologies. It will address the challenges raised by Europe delay in the deployment of network infrastructure and failure to fully benefit from the full potential of digitalisation. It has as main objective to ensure European technological sovereignty in future smart networks and digital services, to strengthen the uptake of digital solutions, and to foster the development of digital innovation that answers to European needs and that are well aligned with societal needs. The study concluded that an institutionalised partnership under article 187 is the preferred option for the implementation of this initiative.

7. Candidate Institutionalised European Partnership in Metrology

This initiative focuses on metrology - that is the science of measurement and the provision of the technical infrastructure that underpins accurate and robust measurements throughout society; measurements that underpin all domains of science and technology and enable fair and open trade and support innovations and the design and implementation of policy and regulations. It will address challenges in the fragmentation of national metrology systems across Europe and the need to meet ever-increasing demands on metrology infrastructure to support the measurement needs of emerging technologies and important policy domains in climate, environment, energy and health. The main objective of the initiative is to establish a sustainable coordinated world-class metrology system in Europe that will increase and accelerate the development and deployment of innovations and contribute to the design and implementation of policy, regulation and standards. The study concluded that an A185 Institutionalised Partnership is the preferred option for the implementation of this initiative.

8. Candidate Institutionalised European Partnership on Transforming Europe's Rail System

This initiative focuses on the development of a pan-European approach to research and innovation in the rail sector. It will address the challenges raised by the lack of alignment of research and innovation with the needs of a competitive rail transport industry and the consequent failure of the European rail network to make its full contribution to European societal objectives. It will also strengthen the competitiveness of the European rail supply industry in global markets. Accordingly, the objectives of the initiative are to ensure a more market-focused approach to research and innovation, improving the competitiveness and modal share of the rail industry and enhancing its contribution to environmental sustainability as well as economic and social development across the European Union. The study concluded that an institutionalised partnership under article 187 is the preferred option for the implementation of this initiative.

9. Candidate Institutionalised European Partnership for Integrated Air Traffic Management

This initiative focuses on the modernisation of the Air Traffic Management in Europe - an essential enabler of safe and efficient air transport and a cornerstone of the European Union's society and economy. The proposed initiative will address the challenges raised by an outdated Air Traffic Management system with a non-optimised performance. The current system needs to be transformed to enable exploitation of emerging digital technologies and to accommodate new forms of air vehicle including drones. The objective is therefore to harmonise European Air Traffic Management system based on high levels of digitalisation, automation and connectivity whilst strengthening air transport, drone and ATM markets competitiveness and achieving environmental, performance and mobility goals. This would create €1,800b benefits to the EU economy if the current initiative can

be built on and accelerated. The study concluded that an Institutionalised Partnership under Art. 187 TFEU is the preferred option for the implementation of this initiative.

10. Candidate Institutionalised European Partnership on Clean Aviation

This imitative focuses on further aeronautical research and innovation to improve technology leading to more environmentally efficient aviation equipment. It will address the challenges raised by the growing ecological footprint of aviation and the challenges and barriers faced by the aviation industry towards climate neutrality. It will also strengthen the competitiveness of the European aeronautical industry in global markets. Accordingly, the objectives of the initiative are to ensure that aviation reaches climate neutrality and that other environmental impacts are reduced significantly by 2050, maintain the leadership and competitiveness of the European aeronautics industry and ensure safe, secure and efficient air transport of passengers and goods. The Impact Assessment study assessed the options for implementation that would allow for an optimal attainment of these objectives. The study concluded that an institutionalised partnership under Art. 187 TFEU is the preferred option for the implementation of this initiative.

11. Candidate Institutionalised European Partnership on Clean Hydrogen

The report assesses the impact of potential initiatives to support, through research and innovation, the growth and development of clean hydrogen, among which an Institutionalised European Partnership is one of the options assessed. The existing challenges for clean hydrogen include the limited high-level scientific capacity and fragmented research activities, the insufficient deployment of hydrogen applications, and consequently weaker EU scientific and industrial value chains. Environmental, health and mobility pressures are also driving the need for cleaner hydrogen generation, deployment and use. An initiative for clean hydrogen must have as a main objective the strengthening and integration of EU scientific capacities, to support the creation, capitalisation and sharing of knowledge. This is necessary to accelerate the development and improvement of advanced clean hydrogen applications, the market entry of innovative competitive clean solutions, to strengthen the competitiveness of the EU clean hydrogen value chains (and notably the SMEs within them), and to develop the hydrogen-based solutions necessary to reach climate neutrality in the EU by 2050. The study concluded that an Institutionalised Partnership under Art. 187 TFEU is the preferred option for the implementation of this initiative.

12. Candidate Institutionalised European Partnership on Safe and Automated Road Transport

This initiative focuses on Connected, Cooperative and Automated Mobility: the use of connected and automated vehicles to create more user-centred, all-inclusive mobility, while also increasing safety, reducing congestion and contributing to decarbonisation. With current road traffic collisions and negative local and global environmental impacts not reducing quickly enough, it will address the challenges raised by the current fragmentation of research across the field, and the threat to European competitiveness if the research agenda does not advance quickly enough. The initiative will focus on strengthening EU scientific capacity and economic competitiveness in the field of CCAM, whilst contributing to wider societal benefits including improved road safety, less environmental impact, and improved accessibility to mobility. The study concluded that a co-programmed partnership is the preferred option for the implementation of this initiative.

13. Candidate Institutionalised European Partnership for a Circular Bio-based Europe

This initiative focuses on intensifying research and innovation allowing to replace, where possible, non-renewable fossil and mineral resources with biomass and waste for the production of renewable products and nutrients, in order to drive forward sustainable and climate-neutral solutions that accelerate the transition to a healthy planet and respect

planetary boundaries. It will address the challenges raised by the fact that the EU economy does not operate within planetary boundaries, is not sufficiently circular and is predominantly fossil based. It will also address the insufficient research and innovation (R&I) capacity and cross-sectoral transfer of knowledge and bio-based solutions, as well as risks posed to the European bio-based industry's global competitiveness. The study concluded that Institutionalised European Partnership based upon Article 187 TFEU is the preferred option for the implementation of this initiative.

14. Candidate Institutionalised European Partnership for Innovative SMEs

The initiative is envisaged as a continuation of the Eurostars 2 programme which is managed by the Eureka network. The initiative focuses on international collaborative R&D of innovative companies, facilitated through a network of national funding organisations as included in the Eureka network. The funded projects are bottom-up and involve small numbers of project partners. The candidate partnership addresses a niche issue namely limited opportunities for international bottom-up collaboration. The partnership provides thus an opportunity for SMEs for international R&D collaboration but does not address specific technological, social, or environmental challenges. Its main objective is to improve the competitiveness of European SMEs through collaborative funding. The study concluded that a co-funded partnership is the preferred option for the implementation of this initiative.

PART II. Horizontal studies

1. Horizontal Analysis of Efficiency and Coherence in Implementation

The focus of this report is on the coherence and efficiency in the current European Partnership landscape under Horizon Europe and the potential to enhance efficiency in the European Partnerships' implementation.

European Partnerships are geared towards playing a pivotal role in tackling the complex economic and societal challenges that constitute the R&I priorities of the Horizon Europe Pillar II and are in a unique position to address transformational failures. Multiple potential interconnections and synergies exist between the candidate European Partnerships within the clusters, but few are visible across the clusters.

As for the improvement of the efficiency in implementation of institutionalised partnerships under Art. 187, potential efficiency and effectiveness gains could be achieved with enhanced collaboration. An option for a common back-office sharing operational implementation activities is worth exploring further through a detailed feasibility study in order to assess whether efficiency gains can be made. Ideally this would be co-designed as a common Partnership approach, leading to a win-win situation for all partners.

2. Impact Modelling of the Candidate Institutionalised European Partnerships

This report presents the results of the use of a macroeconomic model to assess the economic and environmental impacts of the preferred options identified in the individual 13 impact assessment studies. The model used is E3ME. It includes explicit representation for each EU Member State with a detailed sectoral disaggregation.

The impact modelling estimated the impacts of the envisaged initiatives at an aggregated as well as individual level. In total, 14 macroeconomic models have been run, one per reviewed initiative with a time horizon of 2035 and one that combines all initiatives with a time horizon of 2050. The results of each of these models were compared with those of a baseline scenario, which corresponds to a situation where the initiatives would be funded through regular Horizon Europe calls rather than European Partnerships.

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Part I. Impact Assessment Studies for the Candidate Institutionalised European Partnerships

1. Overarching Context to the Impact Assessment Studies

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Introduction

This report sets out the overall policy context of the impact assessment studies for the candidate Institutionalised European Partnerships and the methodological framework that was developed for the impact assessment studies.

It describes the changes in approach to the public-private and public-public partnerships under Horizon Europe compared to the previous EU Framework Programmes. An example is the requirement that all envisaged European Partnerships be implemented as either co-programmed, co-funded or institutionalised. The impact assessment studies will consider these three scenarios as the different options to be assessed, in compliance with the Better Regulation guidelines and against the functionalities that the candidate partnerships are expected to fulfil. The report describes the common methodological framework to assess the envisaged initiatives accordingly.

The report also presents the landscape of European Partnerships at the level of Horizon Europe Pillar 2 clusters, which lay the grounds for all of the impact assessment studies except the candidate Institutionalised European Partnership for Innovative SMEs. This analysis is presented in more depth in the report on the 'Horizontal analysis of efficiency and coherence of implementation' in Part II of the Impact Assessment Study report.

The report is structured around two main headings:

- Chapter 1: Background and context to European Partnerships in Horizon Europe and focus of the impact assessment– What is decided
- Chapter 2: The Candidate European Partnerships under Horizon Europe – What needs to be decided

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1 Background and context to European Partnerships in Horizon Europe and focus of the impact assessment– What is decided

1.1 The political and legal context

1.1.1 Shift in EU priorities and Horizon Europe objectives

Horizon Europe is to be set in the broader context of the pronounced **systemic and holistic approach** taken to the design of the new Framework Programme and the overarching Multi-annual Financial Framework (MFF) 2021-27.

The future long-term budget will be a budget for the Union's priorities. In her Political Guidelines for the next European Commission 2019 – 2024, the new President of the European Commission put forward six overarching priorities for the next five years, which reach well beyond 2024 in scope: A European Green Deal; An economy that works for people; A Europe fit for the Digital Age; Protecting our European way of life; A stronger Europe in the world; and A new push for European democracy. These priorities build upon A New Strategic Agenda for 2019–2024, adopted by the European Council on 20 June 2019, which targets similar overarching objectives. Together with the United Nations Sustainable Development Goals (SDGs), they will shape future EU policy responses to the challenges Europe faces and will steer the ongoing transitions in the European economy and society,

The MFF 2021-27 strives to provide a framework that will ensure a more coherent, focused and transparent response to Europe's challenges. A stronger focus on European added value, a more streamlined and transparent budget, more flexibility in order to respond quickly and effectively to unforeseen demands, and above all, an effective and efficient implementation are among the key principles of the MFF. The objective is to strengthen the alignment with Union policies and priorities and to simplify and reform the system in order to "unlock the full potential of the EU budget" and "turn ambitions into reality". Investment from multiple programmes is intended to combine in order to address key crosscutting priorities such as the digital economy, sustainability, security, migration, human capital and skills, as well as support for small businesses and innovation.[1]

These principles underlying the MFF 2021-27 are translated in the intent for Horizon Europe "to play a vital role, in combination with other interventions, for creating new solutions and fostering innovation, both incremental and disruptive." [2] The new Framework Programme finds its rationale in the daunting challenges that Europe is facing, which call for "a radical new approach to developing and deploying new technologies and innovative solutions for citizens and the planet on a scale and at a speed never achieved before, and to adapting our policy and economic framework to turn global threats into new opportunities for our society and economy, citizens and businesses."

In the Orientations towards the first Strategic Plan for Horizon Europe, the need strategically to prioritise and "direct a substantial part of the funds towards the areas where we believe they will matter the most" is emphasised. The Orientations specify, "Actions under Pillar II of Horizon Europe will target only selected themes of especially high impact that significantly contribute to delivering on the political priorities of the Union."

Figure 1, below, which gives an indicative overview of how the EU political priorities are supported under Horizon Europe, shows the major emphasis placed on contributing to the priority 'A European Green Deal', aimed at making Europe the first climate-neutral

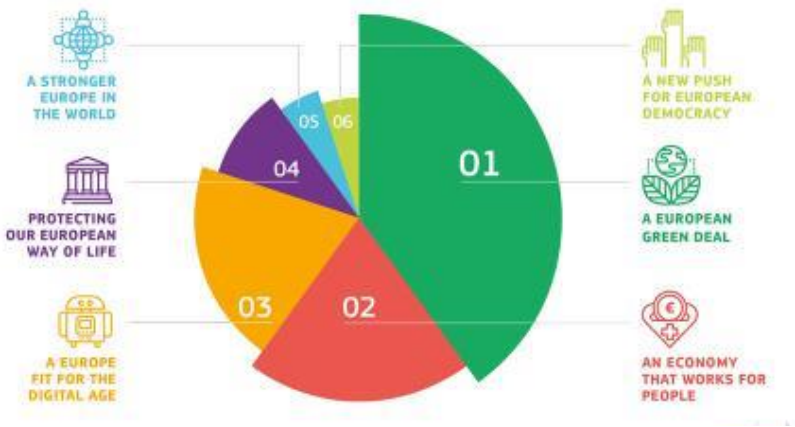
[1] EC (2018) *A Modern Budget for a Union that Protects, Empowers and Defends. The Multiannual Financial Framework for 2021-2027*. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2018) 321 final

[2] EC (2019), *Orientations towards the first Strategic Plan for Horizon Europe*.

continent in the world. At least 35 % of the expenditure from actions under the Horizon Europe Programme will address the Sustainable Development Goal 13: Climate Action.

Especially the R&I activities funded under Pillar II, including seven Partnership Areas (see below), are expected to contribute to the attainment of these objectives in an interconnected manner.

Figure 1: Targeted impacts under Horizon Europe by priority



Note: Preliminary, as described in the General orientations towards the first Strategic Plan implementing Horizon Europe.
Source: European Commission (2019) Orientations towards the first Strategic Plan for Horizon Europe, December 2019.

1.1.2 Renewed ambition for European Partnerships

Reflecting its pronounced systemic nature aimed at 'transformation' of the European R&I system, Horizon Europe intends to make a more effective use of these partnerships with an **ambitious approach** that is impact oriented and ensures complementarity with the Framework Programme. The **rationalisation** of the partnership landscape, both in terms of number of partnership forms and individual initiatives, constituted a first step in the direction of the strategic role that these policy initiatives are expected to play in the context of Horizon Europe. Future partnerships are expected to "provide mechanisms to consistently aggregate research and innovation efforts into more effective responses to the policy needs of the Union".[3] The expectation is that they will act as **dynamic change agents**, strengthening linkages within their respective ecosystems and with other related ecosystems as well as pooling resources and efforts towards the common objectives in the European, national and regional landscape. They are expected to develop *close synergies* with national and regional programmes, bring together a *broad range of actors* to work towards a common goal, translate *common priorities* into concrete roadmaps and coordinated activities, and turn research and innovation into *socio-economic results and impacts*.

The exact budget dedicated to European Partnerships under Horizon Europe will be agreed only upon decisions on the multiannual financial framework (MFF) 2021-2017 and the overall budget for Horizon Europe. In December 2017, the Council nevertheless introduced the principle of a "possible capping of partnership instruments in the FP budget".[4] Accordingly, it reached the common understanding, with the European Parliament, that "the majority of the budget in Pillar II [€52.7bn] shall be allocated to actions outside of

[3] European Commission (2019) *Orientations towards the first Strategic Plan implementing the research and innovation framework programme Horizon Europe*. Co-design via web open consultation. Summer 2019.

[4] Council of the European Union (2017) *From the Interim Evaluation of Horizon 2020 towards the ninth Framework Programme*. Council conclusions 15320/17.

European Partnerships" (Article 8.2(a) of the Common Understanding on the proposal for a regulation establishing Horizon Europe).[5]

1.1.3 Key evolutions as regards the partnership approach

The European R&I partnerships were initially conceived as a means to increase synergies between the European Union and the Member States (Article 181 of the Treaty on the Functioning of the European Union TFEU). Their objectives were to pool the forces of all the relevant actors of R&I systems to achieve breakthrough innovations; strengthen EU competitiveness; and, tackle major societal challenges. The core activities of the European partenrships consist therefore of building critical mass mainly through collaborative projects, jointly developing visions, and setting strategic agendas. They help accelerate the emergence of a programming approach in European R&I with the involvement of all relevant actors and provide flexible structures for partnerships that can be tailored to their goals.[6]

In the consecutive Framework Programmes up to the current Horizon 2020, the partnerships and their forms have mushroomed, leading to an increasing complexity of the partnership landscape. The Horizon 2020 interim evaluation highlighted that the overall landscape of EU R&I funding had become overly complex and fragmented, and a need to improve the partnerships' openness and transparency. The Lamy report suggested that the European Partnerships should focus on those areas with the greatest European Added Value, contribute to EU R&I missions and would need a simplified and flexible co-funding mechanism.

The Competitiveness Council conclusions of December 2017 called on the Commission and the Member States to jointly consider ways to rationalise the EU R&I partnership landscape. In 2018, the ERAC Ad-hoc Working Group on Partnerships concluded, "the rationalisation of the R&I partnership landscape is needed in order to ensure that the portfolio of R&I partnerships makes a significant contribution to improving the coherence, functioning and quality of Europe's R&I system and that the individual initiatives are able to fully achieve their potential in creating positive scientific and socio-economic impacts and/or in addressing societal challenges".

Horizon Europe has taken on board these concerns. The Impact Assessment of Horizon Europe gave a clear analysis of the achievements of Partnerships so far as well as the expectations for the new generation of Partnerships. Greater transparency and openness of the partnerships were considered as essential, as well a clear European added value and long-term commitments of the stakeholders involved.

A list of criteria to decide how European Partnerships will be selected, implemented, monitored, evaluated and phased-out was attached as an Annex III to the proposal to establish Horizon Europe (as revised by the partial political agreement). The rationalisation of the Partnership portfolio in Horizon Europe is expected to allow for a reduction from the current 120 to between 45 and 50 partnerships.

[5] Council of the European Union (2019) *Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing Horizon Europe – the Framework Programme for Research and Innovation, laying down its rule for participation and dissemination*. Common understanding 7942/19.

[6] European Commission (2011) Partnering in Research and Innovation. Communication from the Commission COM(2011) 572 final.

1.1.4 Overview of legal provisions

The Horizon Europe Regulation (common understanding) defines 'European Partnership' as "an initiative where the Union, prepared with early involvement of Member States and/or Associated Countries, together with private and/or public partners (such as industry, universities, research organisations, bodies with a public service mission at local, regional, national or international level or civil society organisations including foundations and NGOs), commit to jointly support the development and implementation of a programme of research and innovation activities, including those related to market, regulatory or policy uptake." It stipulates that "parts of Horizon Europe may be implemented through European Partnerships".

The Horizon Europe Regulation (common understanding) also stipulates that the European Partnerships are expected to adhere to the "principles of Union added value, transparency, openness, impact within and for Europe, strong leverage effect on sufficient scale, long-term commitments of all the involved parties, flexibility in implementation, coherence, coordination and complementarity with Union, local, regional, national and, where relevant, international initiatives or other partnerships and missions." The provisions and criteria set out for the selection and implementation of the European Partnerships reflect these principles.

1.1.5 Overview of the eight Partnership areas

The Horizon Europe Regulation also identifies the following "Areas for possible institutionalised European Partnerships on the basis of Article 185 TFEU or Article 187 TFEU":

- Partnership Area 1: Faster development and safer use of health innovations for European patients, and global health.
- Partnership Area 2: Advancing key digital and enabling technologies and their use, including but not limited to novel technologies such as Artificial Intelligence, photonics and quantum technologies.
- Partnership Area 3: European leadership in Metrology including an integrated Metrology system.
- Partnership Area 4: Accelerate competitiveness, safety and environmental performance of EU air traffic, aviation and rail.
- Partnership Area 5: Sustainable, inclusive and circular bio-based solutions.
- Partnership Area 6: Hydrogen and sustainable energy storage technologies with lower environmental footprint and less energy-intensive production.
- Partnership Area 7: Clean, connected, cooperative, autonomous and automated solutions for future mobility demands of people and goods.
- Partnership Area 8: Innovative and R&D intensive small and medium-sized enterprises.

Considering the realm of these partnership areas, potential synergies exist with the future **missions**. Horizon European introduced these cross-discipline and cross-sector policy instruments as part of its core objective of stimulating further excellence-based and impact-driven R&I. In contrast with the challenges targeted in Horizon 2020, the missions aim at the achievement of well-defined goals to provide solutions, within a specified timeframe, to scientific, technological, economical and/or societal problems. As part of the preparation of Horizon Europe, the European Commission set up five boards to formulate the future missions in the following areas:

- Adaptation to climate change including societal transformation

- Cancer
- Healthy oceans, seas, coastal and inland waters
- Climate-neutral and smart cities
- Soil health and food

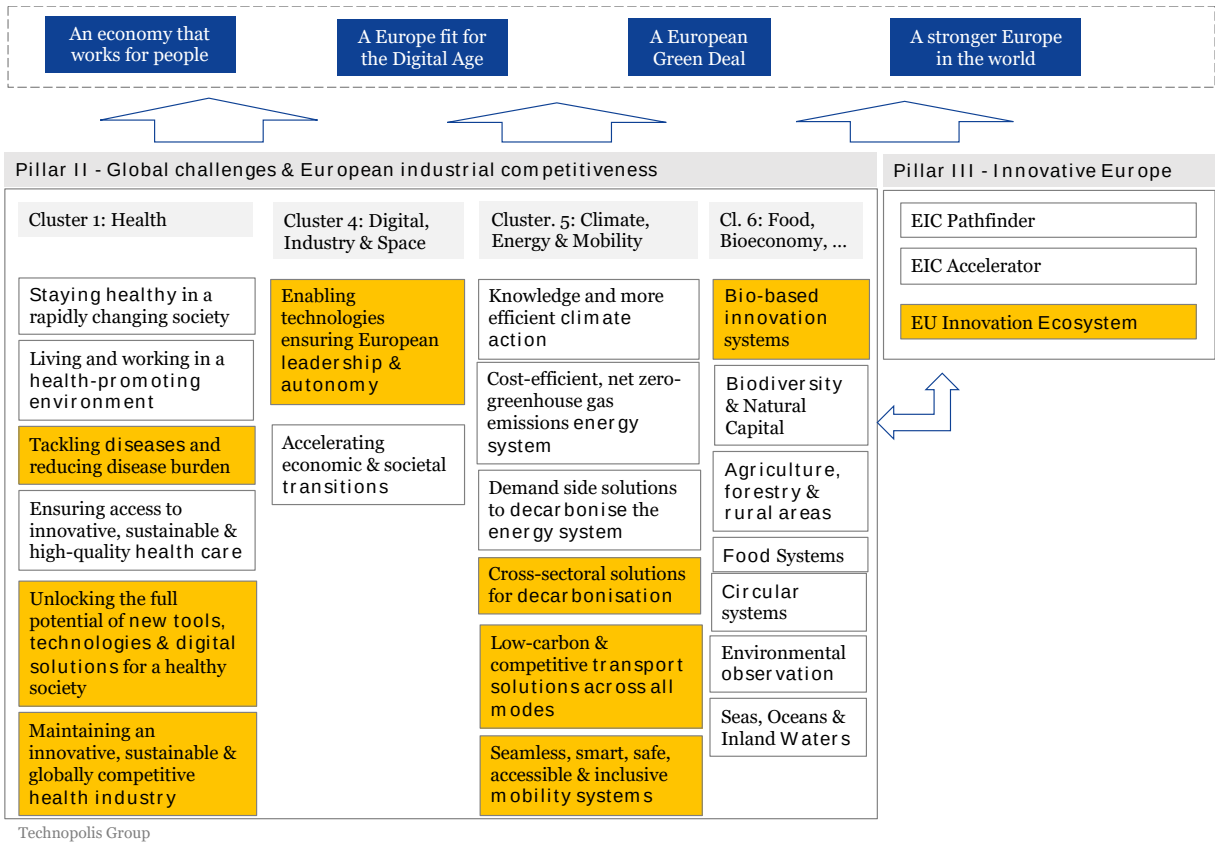
1.2 Typical problems and problem drivers

The European Partnerships are integral part of the framework programme and its three-pillar structure. They are predominantly funded under Pillar 2 "Global Challenges and European industrial competitiveness" and four of its thematic clusters. These clusters cover sectors and technologies, in which research and innovation activities are deemed of crucial importance in solving pressing scientific, societal or economic challenges and ensuring the scientific, technological and industrial leadership of Europe. Only one European Partnership, targeting innovative and R&D intensive SMEs, will instead act under Pillar 3 "Innovative Europe".

The European Partnerships are intended to contribute to the attainment of the pillars' and clusters' **challenges and R&I priorities**. Overarching EU policy priorities addressed are predominantly the European Green Deal, a people-centred economy, the fit for the Digital Age, and a stronger Europe in the world.

In Figure 2, below, the R&I priorities in the Pillars II and III to which the candidate *Institutionalised* Partnerships intend to contribute are highlighted in yellow.

Figure 2: Contribution of Candidate European Institutionalised Partnerships to the Horizon Europe priorities in Pillars II and III



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The European Partnerships under Horizon Europe most often find their rationale in addressing **systemic failures**. Their primary function is to create a platform for a strengthened collaboration and knowledge exchange between various actors in the European R&I system and an enhanced coordination of strategic research agenda and/or R&I funding programmes.

The concentration of efforts and resources and pooling of knowledge, expertise and skills on common priorities in a view of solving complex and multi-faceted societal and economic challenges is at the core of these initiatives. Enhanced cross-disciplinary and cross-sectoral collaboration and an improved integration of value chains and ecosystems are among the key objectives of these policy instruments. In the light of Horizon Europe, the aim often is to drive system transitions and transformations.

Especially in fast-growing technologies and sectors such as ICT, the envisaged European Partnerships also react on emerging opportunities and address systemic failures such as shortage in skills or critical mass or cross-sectoral cooperation along the value chains that would hamper attainment of future European leadership and/or strategic autonomy.

Transformational failures addressed aim at reaching a better alignment of the strategic R&I agenda and policies of public and private R&I funders in order to pool available resources, create critical mass, avoid unnecessary duplication of research and innovation efforts, and leverage sufficiently large investments where needed but hardly achievable by single countries.

Market failures are less commonly addressed and relate predominantly to enhancing industry investments thanks to the sharing of risks.

1.3 Description of the options

The proposal for a regulation establishing Horizon Europe[7] stipulates that parts of the Horizon Europe Framework Programme may be implemented through European Partnerships and establishes three implementation modes: Co-programmed European Partnerships, Co-funded European Partnerships, and Institutionalised Partnerships in accordance with Article 185 TFEU or Article 187 TFEU.

1.3.1 Baseline option – Traditional calls under the Framework Programme

Under this option, strategic programming for research and innovation in the field will be done through the mainstream channels of Horizon Europe. The related priorities will be implemented through traditional calls under the Framework Programme covering a range of activities, but mainly calls for R&I and/or innovation actions. Most actions involve consortia of public and/or private actors in ad hoc combinations, some actions are single actor (mono-beneficiary). There will be no dedicated implementation structures and no further support other than the Horizon Europe actions foreseen in the related Horizon Europe programme or cluster.

Strategic planning mechanisms in the Framework Programmes allow for a high level of flexibility in their ability to respond to particular needs over time, building upon additional input in co-creation from stakeholders and programme committees involving MS. The broad scope of the stakeholders providing their input to the research agenda, however, implies a lower level of directionality than what can be achieved through the partnerships. Often, the long-term perspective of the stakeholder input is limited, which risks reducing strategic capacity in addressing priorities.

The Horizon Europe option also implies a lower level of EU budgetary long-term commitment for the priority. Without a formal EU partnership mechanism, it is also less likely that the stakeholders will develop a joint Strategic Research Agenda and commit to its implementation or agree on mutual financial commitments beyond the single project participation.

[7] Proposal for a Regulation of the European Parliament and of the Council stablishing Horizon Europe - the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination - Common understanding', March 2019

1.3.2 European Partnership

All European Partnerships will be designed in line with the new policy approach for more objective-driven and impactful partnerships. They are based on the common criteria in Annex III of the Horizon Europe Regulation, with few distinguishing elements for the different forms of implementation. All European Partnerships will be based on an agreed Strategic Research and Innovation Agenda / roadmap agreed among partners and with the Commission. For each of them the objectives, key performance and impact indicators, and outputs to be delivered, as well as the related commitments for financial and/or in-kind contributions of the partners will be defined ex-ante.

Option 1 - Co-programmed European Partnership

This form of European Partnership is based upon a *Memorandum of Understanding* or a *Contractual Arrangement* signed by the European Commission and the private and/or public partners. Private partners are typically represented by one or more industry association, which also functions as a back-office to the partnership. It allows for a *high flexibility* in the profile of organisation involved, objectives pursued, and/or activities implemented.

Co-programmed European Partnerships address *broader communities* across a diverse set of sectors and/or value chains and where the actors have *widely differing capacities and capabilities*. They may encompass one or more associations of organisations from industry, research, NGOs etc as well as foundations and national R&I funding bodies, with no restriction on the involvement of international partners from Associated and non-associated third countries. Different configurations are possible: private actors only, public entities only, or a combination of the two.

The basis, as for all European Partnerships, is the rationale is to create a *platform for 'concertation'*, i.e. in-depth and ongoing consultation of the relevant actors in the European R&I system for the co-development of a strategic research and Innovation agenda, typically covering the period of the next 10 years. The primary ambition is to generate *commitment to a common strategic research and innovation agenda* (SRIA). For the private actors involved, this would allow for a de-risking of their R&I investments and provide predictability of investment paths, for the public actors, it serves as a means to: inform national policy-makers on EU investments and allows for coordination and alignment of their efforts to support R&I in the field at the national level.

The *level of 'additionality is possibly lower than for other partnerships*. There is no expectation of a legally binding commitment from the partners to taking an integrated approach in their individual R&I implementation and it is based on 'best efforts'. However, the Union contribution to the partnership is defined for the full duration and has a comparable level of certainty for the partnerships than in the other forms of implementation. The priorities for the calls, proposed by the partnership members for integration in the Framework Programme Work Programmes, are subject to further input from Member States (comitology) and Commission Services. The full implementation of the Union contribution in the Framework Programme implies that the full array of Horizon Europe funding instruments in the related Pillar can be used, ranging from RIAs to CSAs and including grants, prizes, and procurement.

Option 2 – Co-funded European Partnership

The Co-funded Partnership is based on a Grant Agreement between the Commission and the consortium of partners, resulting from a call for a proposal for a programme co-fund action implementing the European Partnerships in the Horizon Europe Work Programme. Programme co-fund actions provide co-funding to a programme of activities established and/or implemented by entities managing and/or funding research and innovation programmes. Therefore, this form of implementation only allows to address public partners

at its core (comparable to the Article 185 initiatives below), while industry can nevertheless be addressed by the activities of the partnerships, but not make formal commitments and contributions to it. The expectation is that these entities would cover most if not all EU Member States (MS). Also 'international' funding bodies can participate as partners, which creates the potential for an efficient interaction with strategic international partners. Legal entities in countries that are not part of the programme co-fund consortium, are usually excluded from funding under the calls launched by the consortium.

The basic rationale for this partnership option is to bring MS together to invest at scale in key R&I issues of general and common interest. The joint programme of activities is agreed by the partners and with the EU and typically focuses on societal grand challenges and specifically, areas of high public good where EU action will add value while reflecting national priorities and/or policies. The ultimate intent is to create the greatest possible impact by pooling and/or coordinating national programmes and policies with EU policies and investments, helping to overcome fragmentation of the public research effort. Member States that are partners in this partnership become the 'owners' of the priority and take sole responsibility for its funding. Commitments of the partners and the European Union are ensured through the Grant Agreement.

Based on national programmes, this partnership option shows a particularly high level of flexibility in terms of activities to be implemented - directly by the national funding bodies (or governmental organisation "owning" institutional programmes), or by third parties receiving financial support (following calls for proposals launched by the consortium). The broad range of possible activities include support for networking and coordination, research, innovation, pilot actions, and innovation and market deployment actions, training and mobility actions, awareness raising and communication, dissemination and exploitation, any relevant financial support, such as grants, prizes, procurement, as well as Horizon Europe blended finance or a combination thereof.

Option 3 – Institutionalised European Partnership

This type of Partnership is the most complex and high-effort arrangement and will be based on a Council Regulation (Article 187) or a Decision by the European Parliament and Council (Art 185) and implemented by dedicated structures created for that purpose. The legal base for this type of partnership limits the flexibility for a change in core objectives, partners, and/or commitments as these would require amending legislation.

The basic rationale for this type of partnership is the need for a strong integration of R&I agenda's in the private and/or public sectors in Europe in order to address a strategic challenge or realise an opportunity. The focus is on major long-term strategic challenges and priorities beyond the framework of a single Framework Programme where collective action – by private and/or public sectors – is necessary to *achieve critical mass* and *address the full extent of the complexities* of the ecosystem concerned.

The long-term commitment expected from the European Union and its partners is therefore much larger than for any of the other options, given the considerably higher investment in the preparation and implementation of the Partnership. As a result, this type of partnership can be selected only if other parts of the Horizon Europe programme, including other forms of European Partnerships, would not achieve the objectives or would not generate the necessary expected impacts. The commitment for contributions by the partnership members is expected to be at least equal to 50% and may reach up to 75% of the aggregated European Partnership budgetary commitments.

The partnership members have a high degree of autonomy in developing the strategic research agenda and annual work programmes and call topics, based on a transparent and accessible process, and subject to the approval of the Commission Services. The choice of topics addressed in the (open) calls are therefore strongly aligned with the needs defined. Normally, the strategic priorities are fully covered by the annual work programmes in the

partnership, even though it is in principle possible to keep certain topics for calls in the FP thus complementing the activities in the partnership. The full integration in the Framework Programme implies that the full array of Horizon Europe funding instruments in the related Pillar can be used, ranging from RIAs to CSAs and including grants, prizes, and procurement.

Two forms of Institutionalised Partnerships are of direct relevance to this study, influencing the constellation of partners involved.

Institutionalised Partnerships based upon Art 185 TFEU

Article 185 of the TFEU allows the Union to participate in programmes jointly undertaken by Member States and limits therefore the scope of partners to Member States and Associated Third countries. This type of Institutionalised Partnership aims therefore at reaching the greatest possible impact through the integration of national and EU funding, aligning national strategies in order to optimise the use of public resources and overcome fragmentation of the public research effort.

It brings together R&I governance bodies of most if not all EU Member States (legal requirement: at least 40% of Member States) as well as Associated Third Countries that designate a dedicated legal entity (Dedicated Implementation Structure) for the implementation. By default, membership of non-associated Third Countries is not foreseen. Such membership is possible only if it is foreseen in the basic act and subject to conclusion of an international agreement. Eligibility for participation and funding follows by default the rules of the Framework programme, unless a derogation is introduced in the basic act.

Institutionalised Partnerships under Art. 187 TFEU

This type of Institutionalised Partnership aims at reaching the greatest possible impact by integrating the strategic R&I agendas of private and/or public actors and by leveraging the partners' investments in order to tackle R&I and societal challenges and/or contribute to Europe's wider competitiveness goals.

It brings together a stable set of partners with a strong commitment to taking a more integrated approach and requires the set-up of a dedicated legal entity (Union body, Joint Undertaking) that carries full responsibility for the management of the partnership and implementation of the calls.

Different configurations are possible: partnerships focused on creating strategic industrial partnerships where, most often, the partner organisations are represented by one or more industry associations, or in some cases individual private partners; partnerships coordinating national ministries, public funding agencies, and governmental research organisations in the Member States and Associated Countries; or a combination of the two (the so-called tripartite model). By default, membership of non-associated Third Countries is not foreseen. Such membership is possible only if it is foreseen in the basic act and subject to conclusion of an international agreement. Eligibility for participation and funding follows by default the rules of the Framework programme, unless a derogation is introduced in the basic act.

2 The Candidate European Partnerships under Horizon Europe – What needs to be decided

2.1 Portfolio of candidates for Institutionalised Partnerships under Horizon Europe

2.1.1 The process for identifying the priorities for Institutionalised Partnerships under Horizon Europe

In May 2019, the European Commission consulted the Member States on a list of 44 possible candidates for European Partnership which it had identified as part of the preparation of the first Strategic Planning of Horizon Europe. This list was also part of the

Orientations towards the first Strategic Plan implementing Horizon 2020[8] which served as a basis for an Open Public Consultation from July to October 2019. In October and November 2019, the European Commission and the Member States agreed on increasing the number of candidate European partnerships to 49. Subsequent discussions until the adoption of Horizon Europe will focus on ensuring the overall consistency of the EU partnership landscape and its alignment with the EU overarching priorities and on defining the precise implementation modalities.

In parallel, the European Commission completed inception impact assessments on the candidate institutionalised European partnerships. Stakeholders had the opportunity to provide their feedback on these inception impact assessments in August 2019. A web-based open public consultation to collect opinions on all candidate institutionalised partnerships (but the candidate EuroHPC partnership) was organised between September and October 2019.

2.1.2 Overview of the overall landscape of candidate European Partnerships subject to the impact assessment

Figure 3, below, gives an overview of all European Partnerships that are currently envisaged for funding under Horizon Europe. The candidate Institutionalised Partnerships that are the subject for this impact assessment study are coloured in dark orange.

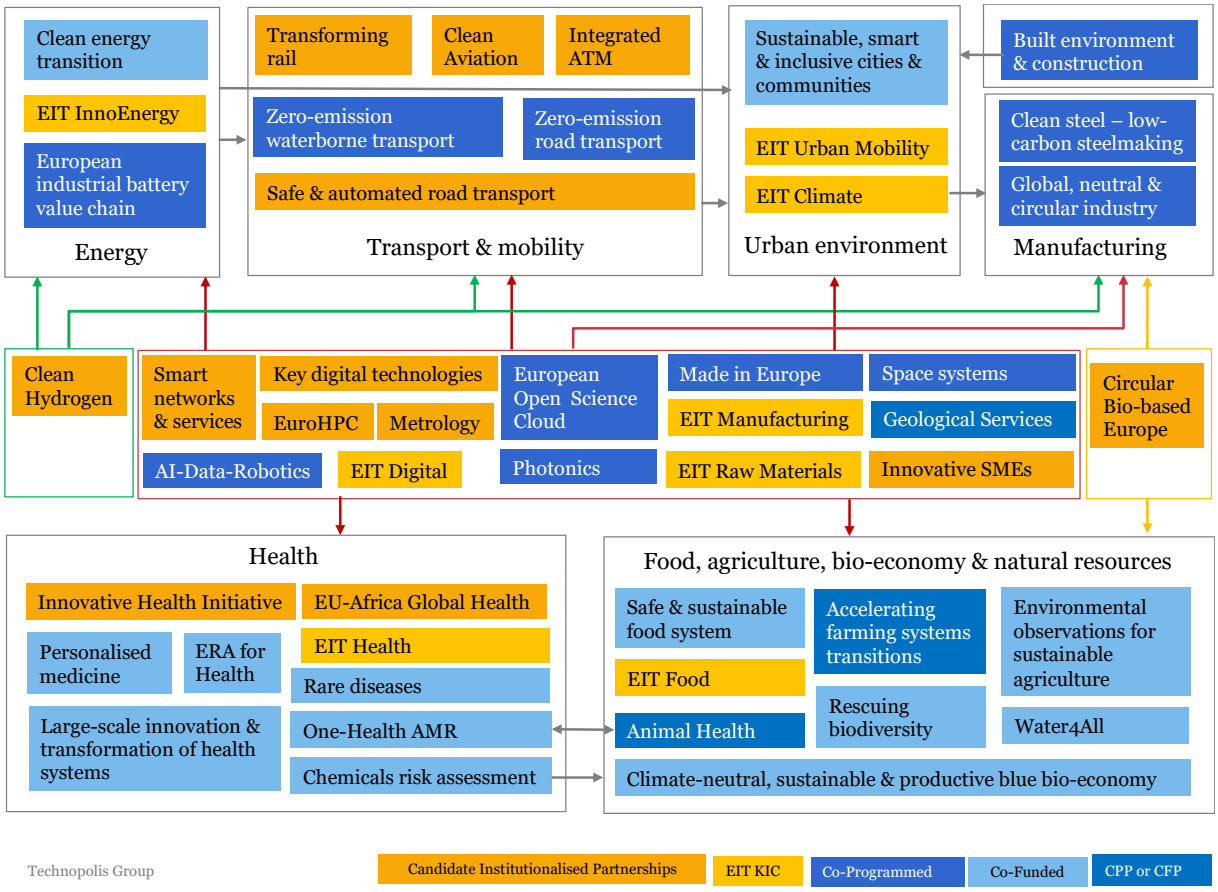
The European Partnerships can be categorised into two major groupings: *'horizontal' partnerships* focused on the development of technologies, methods, infrastructures and resources/materials, and *'vertical' partnerships* focused on the needs and development of a specific application area, be it industrial or societal.

The diagram below shows the central position of the **'horizontal' partnerships** in the overall landscape, developing methodologies, technologies or data management infrastructures for application in the other priority areas. These 'horizontal' partnerships are predominantly proposed as Institutionalised or Co-programmed Partnerships, in addition to a number of EIT KICs. The European Open Science Cloud (EOSC) partnership, for example, will support research partnerships by providing an infrastructure for the storage, management, analysis and re-use of research data.

The upper banner of the diagram groups the **industry-oriented 'vertical' partnerships**. Under Horizon Europe, they have in common a pronounced focus on enhancing sustainability. In this context, the banner includes also one of the most recent agreed-upon partnerships focused on the urban environment. This partnership illustrates the introduction under Horizon Europe of *challenge-oriented* cross-cluster partnerships. Multiple interconnections are envisaged among the 'vertical' partnerships in the different industry sectors covered. In the transport sector, the partnerships are predominantly proposed as Institutionalised Partnerships. In the other sectors, we see a mix of Co-Programmed Partnerships and EIT KICs. There are only two Co-Funded Partnerships.

[8] Orientations towards the first Strategic Plan implementing the research and innovation framework programme Horizon Europe, Co-design via Web Open Consultation (2019), see more here https://ec.europa.eu/research/pdf/horizon-europe/ec_rtd_orientations-towards-the-strategic-planning.pdf

Figure 3: Landscape of European Partnerships under Horizon Europe (2019)



The lower banner includes the '**vertical' partnerships in the societal application areas**. Striking is the dominance of the Co-Funded Partnerships (to be noted that in the Food/agriculture cluster, the partnership type still needs to be decided for several envisaged partnerships). We also note the limited interconnections that are envisaged between the two areas. An exception is the newly envisaged cross-cluster European Partnerships 'One Health AMR'.

2.2 Assessing the necessity of a European Partnership, possible options for implementation and their cost-effectiveness

In this section we set out the methodological framework that underpins the impact assessment studies. In line with the Better Regulation Guidelines, the impact assessment is intervention logic-based and impact-oriented.

The impact assessment allowed also for the conduct of the 'necessity test' for a European Partnership as set out in the Horizon Europe regulation. Pivotal in this context was the identification of the Horizon Europe calls as Option 0 as well as Baseline Option, allowing for a comparative analysis of the three partnership forms (Options 1-3) along all of the assessment dimensions – in relation to each other as well as to the Horizon Europe calls. The options assessment therefore incorporated the required 'necessity test'.

2.2.1 Assessment of the selection criteria

The common methodological framework that we defined for the 13 individual Impact Assessment studies reflects the approach defined in the Better Regulation guidelines. It also integrates the specific criteria for the use of the different types of European Partnerships as they are defined in the Horizon Europe Common Understanding (Article 8 and Annex III). Specifically this regards the **selection criteria** which have to be demonstrated as a minimum in order to justify the necessity of a European Partnership instead of regular Horizon Europe calls only and the implementation criteria in Article 8

1(a), (b) and (c) with certain elements distinguishing the use of the different partnership implementation modes (Table 1).

Table 1: Horizon Europe selection criteria for the European Partnerships

Common selection criteria and principles	Specifications
More effective (Union added value) clear impacts for the EU and its citizens	• delivering on global challenges and research and innovation objectives
	• securing EU competitiveness
	• securing sustainability
	• contributing to the strengthening of the European Research and Innovation Area
	• where relevant, contributing to international commitments
Coherence and synergies	• within the EU research and innovation landscape
	• coordination and complementarity with Union, local, regional, national and, where relevant, international initiatives or other partnerships and missions
Transparency and openness	• identification of priorities and objectives in terms of expected results and impacts
	• involvement of partners and stakeholders from across the entire value chain, from different sectors, backgrounds and disciplines, including international ones when relevant and not interfering with European competitiveness
	• clear modalities for promoting participation of SMEs and for disseminating and exploiting results, notably by SMEs, including through intermediary organisations
Additionality and directionality	• common strategic vision of the purpose of the European Partnership
	• approaches to ensure flexibility of implementation and to adjust to changing policy, societal and/or market needs, or scientific advances, to increase policy coherence between regional, national and EU level
	• demonstration of expected qualitative and significant quantitative leverage effects, including a method for the measurement of key performance indicators
	• exit-strategy and measures for phasing-out from the Programme
Long-term commitment of all the involved parties	• a minimum share of public and/or private investments
	• In the case of institutionalised European Partnerships, established in accordance with article 185 or 187 TFEU, the financial and/or in-kind, contributions from partners other than the Union, will at least be equal to 50% and may reach up to 75% of the aggregated European Partnership budgetary commitments

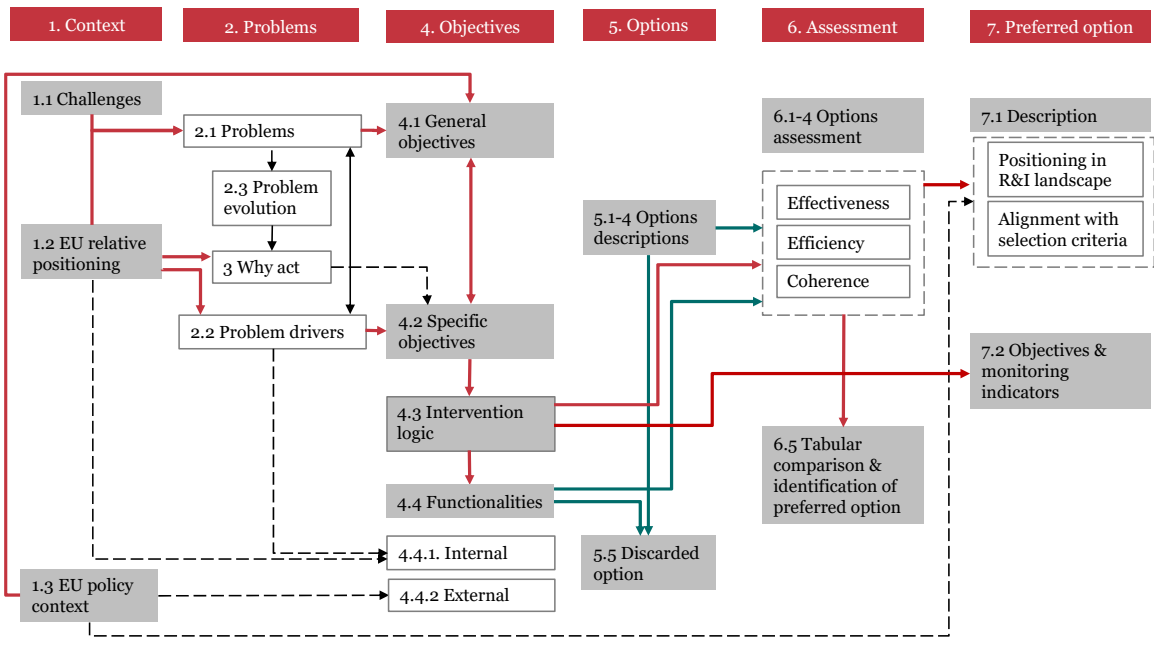
The **Better Regulation guidelines** remained the primary point of reference for the 13 individual Impact Assessment studies. The different steps of the IA process were carried out in a consistent manner in the 13 individual IA studies, supported by horizontal analyses (i.e. common to all studies) such as bibliometrics/patent analysis, social network analysis, the partnership portfolio mapping and analysis, as well as the analysis of the Open Public Consultation data.

The **selection criteria** for the European Partnerships related to effectiveness and coherence fit reasonably well in the Better Regulation impact assessment structure. More problematic was the coverage of the other three criteria groupings, i.e. the criteria of Openness and Transparency, Additionality and Directionality, and the Ex-ante demonstration of commitment.

The solution was the introduction of a section on the **'Functionalities of the initiative'**, in which set out our view on *how* the initiative should *concretely* respond to the selection criteria of 'coherence and synergies', 'openness and transparency' and 'additionality and directionality' in order to reach its objectives. We focused on those aspects that are not covered in other sections of this report, such as coherence and synergies, and covered those elements that from our analysis of the partnership options resulted being **key distinguishing features** of the partnership options, i.e. the composition of the partnership ('openness', including from a geographical perspective), the type of activities implemented ('flexibility'), and the level of directionality and integration of the stakeholders' R&I strategies needed ('directionality and additionality').

The logical process is summarised in Figure 4, below. The diagram shows how the 'functionality' sections constituted an important passage from the objectives and intervention logic sections to the options assessment. Building upon information collected in the previous sections (context, problem and objectives analysis) and in combination with the description of the available options, the description of the desirable 'functionalities' allowed for, on the one hand, the identification of the discarded option(s) and, on the other hand, the options assessment against coherence and against the selection criteria of 'Openness and Transparency' and 'Additionality and Directionality'. In the final chapter of the Impact Assessment report, the alignment of the preferred option with the criteria for the selection of European Partnerships was described, emphasising the outcomes of the 'necessity test'.

Figure 4: Flow of the analysis



Notes: the numbers indicate the related chapters or sections in the Impact Assessment reports

2.2.2 Methodological approach

Overview of the methodologies employed

The understanding of the overall context of the candidate institutionalised European Partnerships relies on a desk research partly covering the main impacts and lessons learned

from their predecessor partnerships (if any). This was complemented with a set of quantitative analyses of the Horizon 2020-funded partnerships, or in case these did not exist, the H2020-funded projects in the field. The analyses included a portfolio analysis, a stakeholder and social network analysis in order to profile the actors involved as well as their co-operation patterns, and an assessment of the partnerships' outputs (bibliometrics and patent analysis). A cost modelling exercise was performed in order to feed into the efficiency assessments of the partnership options (see below).

Public consultations (open and targeted) supported the comparative assessment of the policy options. Each study interviewed up to 50 relevant stakeholders (policymakers, business including SMEs and business associations, research institutes and universities, and civil organisations, among others). They also used the results from the Open Public Consultation organised by the European Commission (Sep – Nov 2019) and the feedback on the Inception Impact Assessments of the 13 candidate institutionalised European Partnerships that the European Commission received in September 2019.

The timing of the Impact Assessment studies, in parallel to the negotiations between the European Commission and the existing Joint Undertakings on the specific implementation of the rules for the future European Partnership, as well as the ongoing discussions within the existing partnership on their future research directions, has set potential limits to the validity of the input and feedback collected from the stakeholders during the consultations.

A more detailed description of the methodology is provided in the Annexes C of each impact assessment report.

Method for identifying the preferred choice

The four policy options were compared along a range of key parameters. The comparison along these parameters was carried out in an evidence-based manner. A range of quantitative and qualitative evidence was used, including ex-post evaluations; foresight studies; statistical analyses of Framework Programmes application and participation data and Community Innovation Survey data; analyses of science, technology and innovation indicators; econometric modelling exercises producing quantitative evidence in the form of monetised impacts; reviews of academic literature on market and systemic failures and the impact of research and innovation, and of public funding for research and innovation; sectoral competitiveness studies; expert hearings; etc.

Options assessment related to effectiveness and coherence

On the basis of the evidence collected and gathered, the Impact Assessment study teams assessed the effectiveness of the retained policy options along three dimensions corresponding to the different categories of likely impacts: scientific, economic and technologies, and societal (including environmental) impacts. The Impact Assessment study teams considered to which extent the retained policy options fulfilled the desirable 'functionalities' and were therefore likely to produce the targeted impacts. This analysis resulted in a scoring of the policy options along a three-point scale.[9] Instead of a compound score, the assessment of the effectiveness of the policy options concluded on as many scores as there are expected impacts.

Likewise, the impact assessment study teams attributed scores (using the same approach as above) reflecting the potential of each retained policy option for ensuring coherence with programmes and initiatives within (internal coherence) and beyond (external coherence) Horizon Europe.

[9] Scores vary from + to +++, where + refers to low potential for presenting a low potential for reaching the likely impacts, ++ to a good potential, and +++ to a high potential.

Scores were justified in a consistent and detailed manner in order to avoid arbitrariness and spurious accuracy. A qualitative or even quantitative explanation was provided of why certain scores were given to specific impacts.

When assessing the respective efficiency of the retained policy options, the Impact Assessment study teams considered the scores related to effectiveness and the identified costs to conduct a "value for money" (or cost-effectiveness) analysis. They accordingly attributed a comparative score to each of the options ranging from 1 (option with the highest costs) to 3 (options with the lowest costs).

Options assessment related to efficiency

A standard cost model

The 'horizontal' team has reviewed the cost categories and costs for each of the four policy options, at some length. Our first model used published data from past partnerships and Horizon 2020 calls working with the Commission's standard accounting codes (Title 1, Title 2, Title 3). The analysis revealed wide-ranging differences in costs across partnerships and functions, which was thought to be too complex to be helpful to the current exercise. As a result, we created a static, common model using average costs as a means by which to indicate the order of magnitude of effort and thereby reveal the principal differences between each of the policy options.

The model was developed jointly with the European Commission services and is presented in the study Data report (D1.2), along with an explanation of the data sources used and the assumptions made.

It is important to note that the costs identified are theoretical and do not reflect the actual costs of any existing individual partnership. In light of this fact, and to avoid any risk of misunderstanding, we have transposed the financial estimates into a qualitative presentation using + / - system in order to compare the various cost elements for each policy option with the equivalent costs for the baseline policy options (see Table 2).

The principal differences in costs as compared with regular Horizon Europe calls relate to the European Partnerships' one-off costs (e.g. developing the proposal and Strategic Research and Innovation Agenda), additional supervision by the European Commission and any additional programme management effort. The main difference between the three types of European Partnership are twofold: (i) the extent to which a partnership will need to run a limited or comprehensive programme management unit and (ii) the extent to which a new partnership may benefit from a pre-existing programme management unit that will greatly reduce or eliminate the set-up costs that would apply to a wholly new partnership.

Table 2: Intensity of additional costs compared with HEU Calls (for Partners, stakeholders, public and EC)

Cost items	Option 0	Option 1	Option 2	Option 3 -Art. 185	Option 3 -Art. 187
Preparation and set-up costs					
Preparation of a partnership proposal (partners and EC)	0	++	++	++	++
Set-up of a dedicated implementation structure	0	0	0	Existing: + New: ++	Existing: ++ New: +++
Preparation of the SRIA / roadmap	0	++	++	++	++

Cost items	Option 0	Option 1	Option 2	Option 3 -Art. 185	Option 3 -Art. 187
Ex-ante Impact Assessment for partnership	0	0	0	+++	+++
Preparation of EC proposal and negotiation	0	0	0	+++	+++
Running costs (Annual cycle of implementation)					
Annual Work Programme preparation	0	+	0	+	+
Call and project implementation	0	0 In case of MS contributions: +	+	+	+
Cost to applicants	Comparable, unless there are strong arguments of major differences in oversubscription				
Partners costs not covered by the above	0	+	0	+	+
Additional EC costs (e.g. supervision)	0	+	+	+	++
Winding down costs					
EC	0	0	0	0	+++
Partners	0	+	0	+	+

Notes: 0: no additional costs, as compared with the baseline; +: minor additional costs, as compared with the baseline; ++: medium additional costs, as compared with the baseline; +++: higher costs, as compared with the baseline

Rationale for the comparative scoring on 'overall costs' and 'cost-efficiency' in the scorecard

In the scorecard analysis, the scores related to the set-up and implementation costs will allow the study teams to consider the scale of the expected benefits and thereby allow a simple "value for money" analysis (cost-effectiveness).

Table 3 shows how we translated the cost analysis into a series of numerical scores.

Table 3: Cost-efficiency matrix

	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 2: Co-funded	Option 3: Institutionalised
Overall cost	3	2	1	1
Cost-efficiency	3	3	2	2

For the 'overall cost' dimension, we assigned a score 1 to the option with the highest additional costs and a score 3 to the option with the lowest additional costs compared to the baseline. This was based on the following considerations:

- **Horizon Europe regular calls** will have the lowest overall cost among the policy options and have therefore been **scored 3** on this criterion, using a scale of 1-3 where 3 is best (lowest additional costs). This adjudged score is based on two facts: firstly, that Horizon Europe will not entail any additional one-off costs to set up or discontinue

the programme, where each of the other policy options will require at least some additional set-up costs; and secondly, that Horizon Europe will not require any additional running costs, where each of the other policy options will involve additional efforts by the Commission and partners in the carrying out of necessary additional tasks (e.g. preparing annual work programmes).

- A **co-programmed partnership** (Option 1 - CPP) will entail slightly higher overall costs as compared with the baseline policy option and has therefore been given a **score of 2**, using a scale of 1-3 where 3 is best (lowest additional costs). There will be some additional set-up costs linked for example with the creation of a strategic research and innovation agenda (SRIA) and additional running costs linked with the partners role in the creation of the annual work programmes and the Commission's additional supervisory responsibilities. A CPP will have lower overall costs than each of the other types of European Partnership, as it will function with a smaller governance and implementation structure than will be required for a Co-Funded Partnership or an Institutionalised Partnership and – related to this – its calls will be operated through the existing HEU agencies and RDI infrastructure and systems.
- The **Co-Funded Partnership (**Option 2 – CFP) has been **scored 1** on overall cost, using a scale of 1-3 where 3 is best (lowest additional costs). This reflects the additional set-up costs of this policy option and the substantial additional running costs for partners, and the Commission, of the distributed, multi-agency implementation model.
- The **Institutionalised Partnership** (Option 3 - IP) has been **scored 1** on overall cost, using a scale of 1-3 where 3 is best (lowest additional costs). This reflects the substantial additional set-up costs of this policy option – and in particular the high costs associated with preparing the Commission proposal and negotiating that through to a legal document – and the substantial additional running costs for the Commission associated with the supervision of this dedicated implementation model.

In relation to **cost-efficiency**, we considered that while there is a clear gradation in the overall costs of the policy options, the cost differentials are less marked when we take into account financial leverage (co-financing rates) and the total budget available for each of the policy options, assuming a common Union contribution. From this perspective, there are only one or two percentage points that split the most cost-efficient policy options – the baseline and CPP policy options – and the least cost-efficient – the CFP and IP. We have therefore assigned a score of 3 to the baseline Option 0 and CPP options for cost-efficiency (no or minor additional costs, as compared with the baseline) and a score of 2 for the CFP and IP policy options (medium additional costs, as compared with the baseline).

Scorecard analysis for the final options assessment

The scorecard analysis built a hierarchy of the options by individual criterion and overall. The scorecard exercise supported the systematic appraisal of alternative policy options across multiple types of monetary, non-monetary and qualitative dimensions. It also allowed for easy visualisation of the pros and cons of alternative options.

Each option was attributed a value of 1 to 3, scoring the adjudged performance against each criterion with the three broad appraisal dimensions of effectiveness, efficiency and coherence.

Scores were justified in a consistent and detailed manner in order to avoid arbitrariness and spurious accuracy. A qualitative or even quantitative explanation was provided of why certain scores were given to specific impacts, and why one option scores better or worse than others.

The scorecard analysis allowed for the identification of a single preferred policy option or in case of an inconclusive comparison of options, a number of 'retained' options or hybrid. The final selection is a policy decision.

2.3 Cross-partnership challenges in Horizon Europe clusters

In this section we set the envisaged and candidate partnerships in the context of the Horizon Europe clusters and the related higher-level EU policy objectives and priorities. We focus on the evolution of the policy context including the new European Green Deal/climate neutrality objectives, the Horizon Europe Framework relevant to this cluster, and the link to the relevant Sustainable Development Goals. Seeing the focus on the Pillar II clusters, this section excludes the candidate *Institutionalised Partnership for Innovative SMEs*.

2.3.1 Cluster 1 – Health

Research and innovation (R&I) actions under this cluster will aim at addressing the major socio-economic and societal burden that diseases and disabilities pose on citizens and health systems of the EU and worldwide.

The R&I activities funded under the Pillar II Cluster Health aim at contributing to the achievement of the Sustainable Development Goal 'Ensuring healthy lives and promoting well-being for all at all ages' resulting from investments in research and innovation focused on three overarching EU policy objectives: 'An economy that works for people', 'A Europe fit for the Digital Age', and 'A European Green Deal' (see Figure 5, below). The Horizon Europe proposal for a regulation defined the areas for possible institutionalised European partnerships on the basis of Article 185 TFEU or Article 187 TFEU as "*Partnership Area 1: Faster development and safer use of health innovations for European patients, and global health".*

At the core in this cluster are the R&I orientations that aim at ensuring that citizens *stay healthier throughout their lives* due to improved health promotion and disease prevention and the adoption of healthier behaviours and lifestyles, the development of *effective health services* to tackle diseases and reduce their burden, and an improved access to *innovative, sustainable and high-quality health care*. These objectives require an unlocking of the full potential of *new tools, technologies and digital solutions* and ensuring a *sustainable and globally competitive health-related industry* in the EU, allowing for the delivery of, e.g. personalised healthcare services. Last but not least, the citizens' health and well-being need to be *protected from environmental degradation and pollution*, addressing a.o. climate-related challenges to human health and health systems.

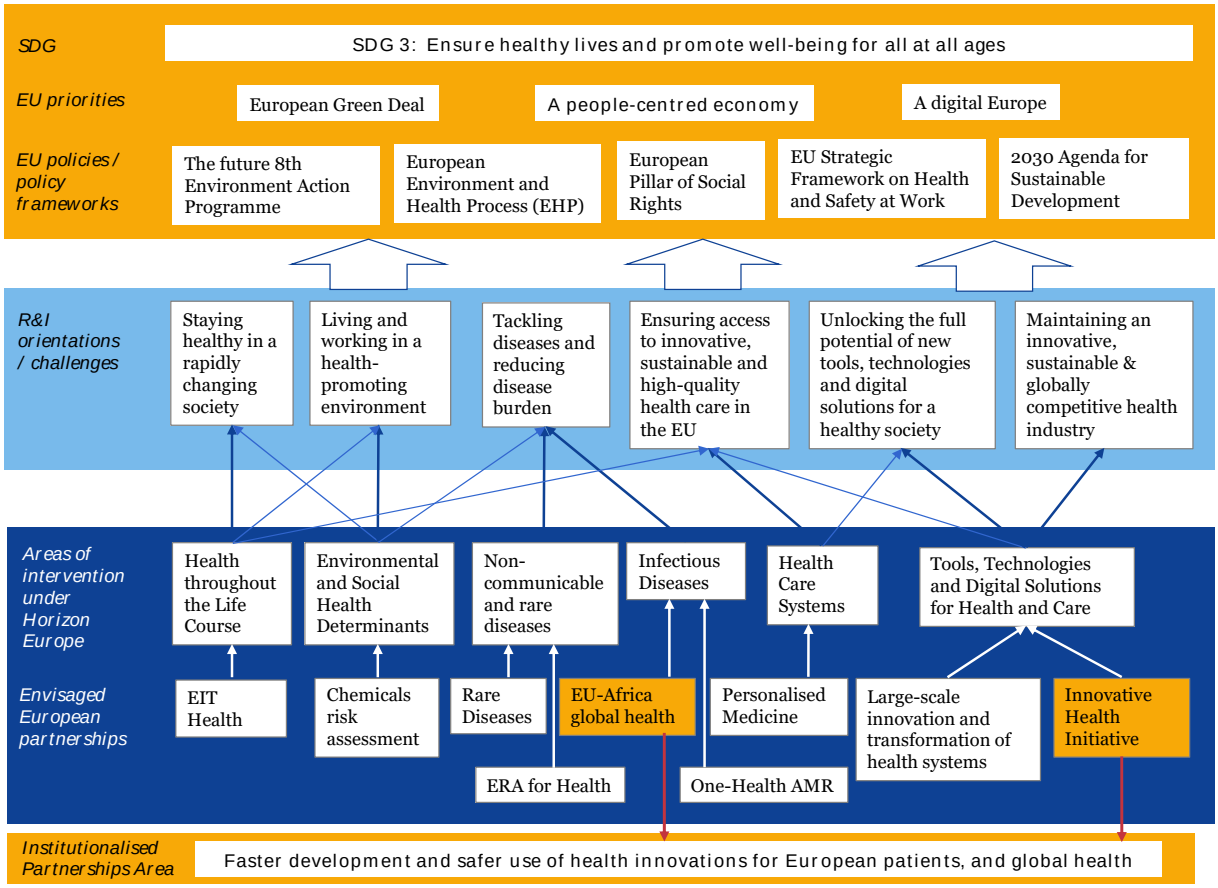
Figure 5, below, shows that the portfolio of envisaged European Partnerships in this cluster[10] aims to contribute to all of the R&I orientations in this cluster. However, there is a pronounced focus on the 'tackling diseases and reducing the disease burden' objective, addressed by five out of the ten partnerships (amongst which there is one candidate Institutionalised Partnership). The objectives focused on an improved exploitation of digital solutions and competitiveness of the EU health-related industry are addressed by two partnerships amongst which one is a candidate Institutionalised Partnership.

In this context, it should be noted that the portfolio of European Partnerships in this cluster predominantly encompasses Co-funded Partnerships, focused on joining the R&I programmes and investments at the national level. There is therefore overall a limited level of involvement of the private sector in the development of the SRIAs (i.e. as partners of the envisaged partnerships), be it from the supply or user side in the value chains. The only exceptions are the Innovative Health Initiative and the EIT KIC Health. European Partnerships also provide limited support for the assessment of environmental and social health determinants, uniquely addressed from a chemical risks perspective.

[10] As proposed in the Horizon Europe 'Orientations towards the first Strategic Plans', dd. December 2019

The description of the interconnections between the partnerships in this cluster and the ones funded in the context of other clusters, provided in the reports of the individual impact assessment studies, sheds more light on this topic.

Figure 5: R&I priorities and higher-level objectives of the Horizon Europe Cluster 1 – Health



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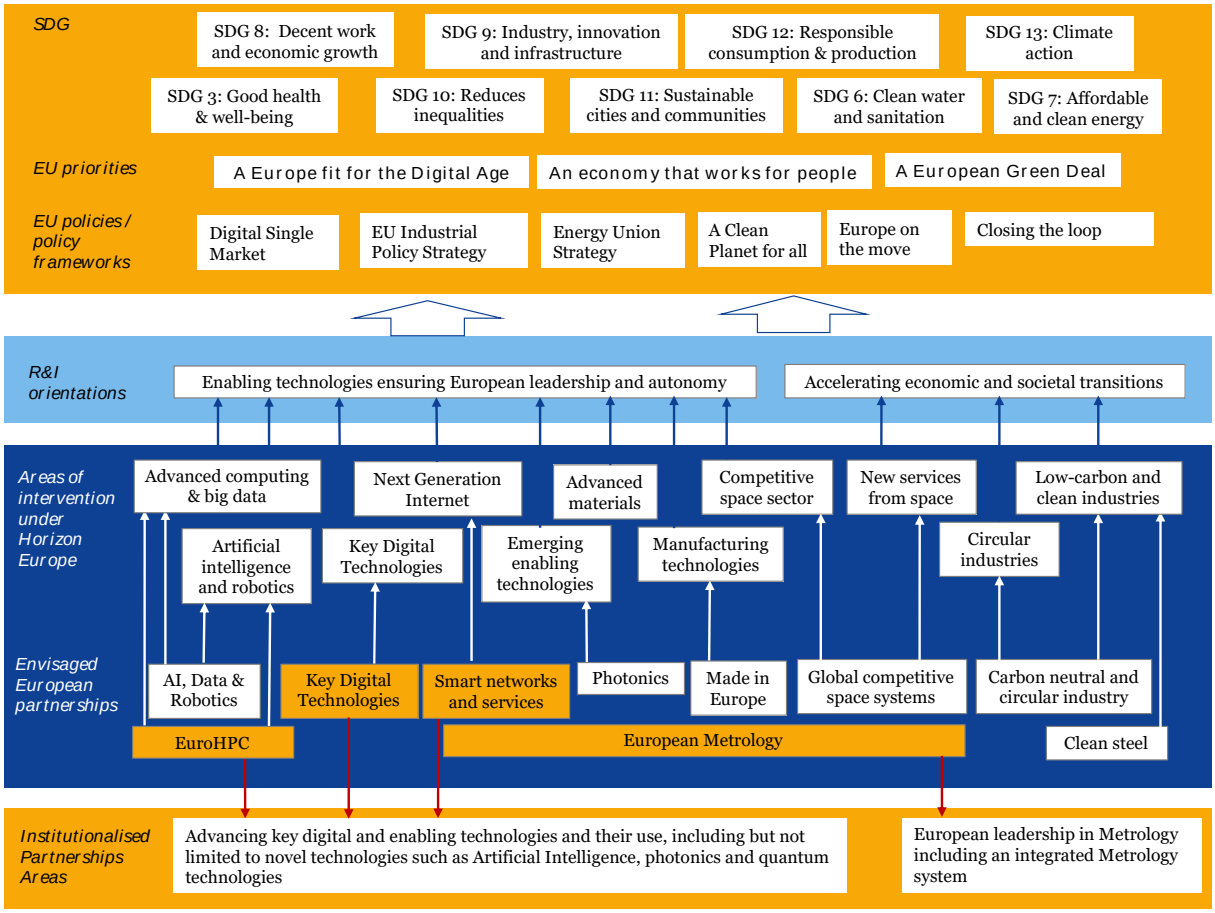
2.3.1 Cluster 4 – Digital, Industry and Space

In this cluster the focus is on the digitisation of European industry and on advancing key enabling, digital and space technologies which will underpin the transformation of our economy and society at large. The overarching vision for R&I investments in this cluster is "a European industry with global leadership in key areas, fully respecting planetary boundaries, and resonant with societal needs – in line with the renewed EU Industrial Policy Strategy." The expected effects on the European economy and society imply that the R&I activities under this cluster will contribute to various Sustainable Development Goals and respond to three key EU policy priorities: 'A European Green deal', 'A Europe fit for the digital age', and 'An economy that works for people' (Figure 6).

The cluster pursues three objectives: 1) ensuring the competitive edge and sovereignty of EU industry; 2) fostering climate-neutral, circular and clean industry respecting planetary boundaries; and 3) fostering social inclusiveness in the form of high-quality jobs and societal engagement in the use of technologies. A human-centred approach will be taken, i.e. technology development going hand in hand with European social and ethical values.

The key R&I priorities are grouped in two general categories: (I) Enabling technologies ensuring European leadership and autonomy; and (II) Accelerating economic and societal transitions (these will be complemented by priorities of other clusters). European Partnerships envisaged to support the R&I in the specific intervention areas are mainly co-programmed partnerships. Exceptions are the three candidate Institutionalised Partnerships in the digital field and the candidate Institutionalised Partnership in metrology, reflecting their related Partnership Areas.

Figure 6: R&I priorities and higher-level objectives of the Horizon Europe Cluster 4 – Digital, Industry and Space



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Multiple convergences exist between the technologies that are covered in the first strand of the priorities in this cluster, i.e. "enabling technologies ensuring European leadership and autonomy". In their function of 'enabling' technologies, they will also make critical contributions to the attainment of the desired 'transitions' in the 'vertical' industry sectors targeted in the second strand of priorities in this cluster as well as in the other clusters. A major contribution from this perspective can be expected from the four candidate Institutionalised Partnerships as well as from the 'Made in Europe' partnership, focused on manufacturing technologies.

2.3.2 Cluster 5 – Climate, Energy and Mobility

The main objectives of this cluster are 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. This is supportive of several Sustainable Development Goals including affordable and clean energy (SDG7); industry, innovation & infrastructure (SDG9); sustainable cities & communities (SDG11); sustainable consumption & production (SDG12); and climate action (SDG13). The cluster is most closely aligned to the EU priority for 'A European Green Deal' but also has synergy with two of the other five priorities; 'An economy that works for people' and 'A Europe fit for the Digital Age'. This extends across various policies including a Clean Planet for all, the Energy Union strategy, Single European Railway Area, European ATM Master Plan, Single European Sky, and Europe on the Move (Figure 7).

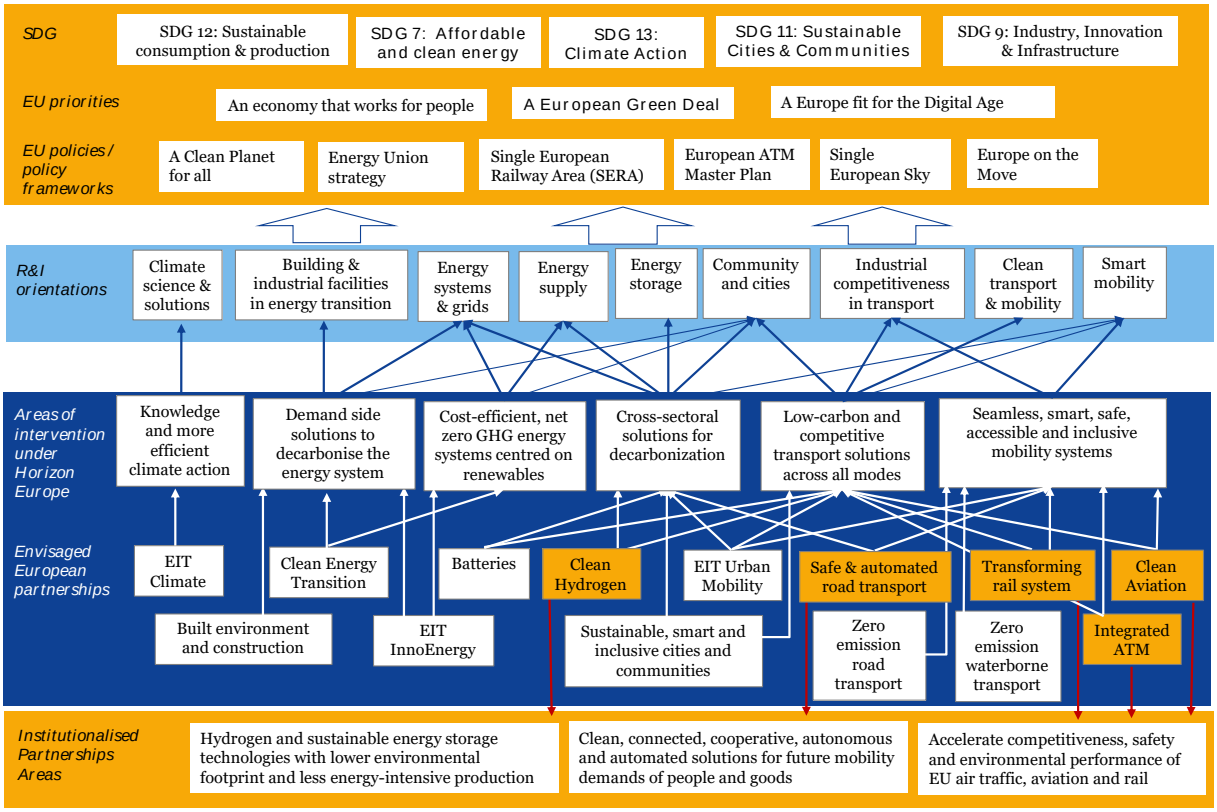
The cluster is directly relevant to several of the areas for possible institutionalised European partnerships on the basis of Article 185 TFEU or Article 187 TFEU, namely:

- Partnership Area 4: Accelerate competitiveness, safety and environmental performance of EU air traffic, aviation and rail

- Partnership Area 6: Hydrogen and sustainable energy storage technologies with lower environmental footprint and less energy-intensive production
- Partnership Area 7: Clean, connected, cooperative, autonomous and automated solutions for future mobility demands of people and goods

Cluster 5 is structured under six areas of intervention under Horizon Europe and nine R&I orientations. Figure 7, below, shows the portfolio of envisaged European Partnerships that are relevant to this cluster and their link to the areas of intervention.

Figure 7: R&I priorities and higher-level objectives of the Horizon Europe cluster Climate, Energy and Mobility



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There are 14 candidate Partnerships that align with this cluster of which eight are possible Institutionalised Partnerships, including five Article 187 initiatives and three EIT-KICs. There are no candidate Article 185 Partnerships in this cluster. The other partnerships are envisaged as either Co-programmed and/or Co-funded Partnerships.

The diagram above shows the strong orientation of the possible Institutional Partnerships towards the mobility area and more limited direct synergies between the envisaged Partnerships and the 'climate science & solutions' priority. Of course, the climate change challenge underpins the whole of this cluster, except where the focus is on industrial competitiveness, but this will also be at least partially dependent on innovation related to clean energy and mobility products and services.

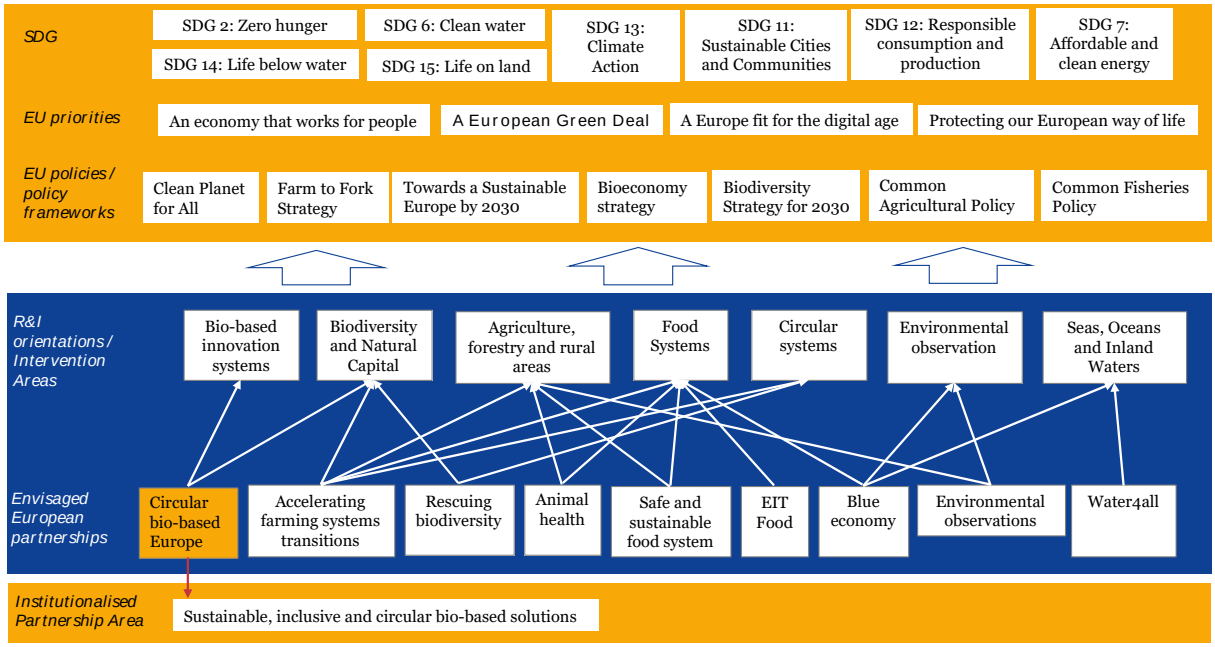
2.3.3 Cluster 6 – Food, Bioeconomy, Natural Resources, Agriculture and Environment

The key objective of Cluster 6, 'Food, Bioeconomy, Natural Resources, Agriculture and Environment' is to advance knowledge, expand capacities and deliver innovative solutions to accelerate the transition towards the sustainable management of natural resources (such as biodiversity, water and soils). The cluster has a large realm and aims to address a wide range of challenges relating to climate change, biodiversity and ecosystems, natural resources, and the production and consumption patterns that may affect them. It encompasses a single area for possible institutionalised European Partnerships aimed at the development of "sustainable, inclusive and circular, bio-based solutions".

The R&I activities funded under the Pillar II Cluster 6 contribute first and foremost to the 'European Green Deal'. More precisely, they will be instrumental to the announced climate change actions, the Biodiversity Strategy for 2030, the "Farm to Fork Strategy", the zero-pollution ambition, the New Circular Economy Action Plan, and the comprehensive strategy on Africa and trade agreements. However, through cooperation with the other clusters, Cluster 6 may make some contribution to the other EU overarching policy priorities. The R&I activities funded under this cluster therefore aim to contribute to the achievement of several United Nations SDGs including: SDG 2: Zero hunger; SDG 6: Clean water and sanitation; SDG 7: Affordable and clean energy; SDG 11: Sustainable cities and communities; SDG 12: Responsible consumption and production; SDG 13: Climate action; SDF 14: Life below water; and, SDG 15: Life on land.

Cluster 6 is structured around six targeted impacts and seven research and innovation orientations, as shown in Figure 8, below. The R&I activities funded under this cluster aim to (1) develop solutions for mitigation of, and adaptation to, *climate change*; (2) halt the *biodiversity* loss and foster the restoration of *ecosystems*; (3) encourage the sustainable (and circular) management and use of *natural resources*; (4) stimulate inclusive, safe and health *food and bio-based systems*; (5) a better understanding of the determinants of *behavioural, socio-economic and demographic changes* to accelerate system transformation; and, (6) improve solutions for *environmental observations and monitoring systems*.

Figure 8: R&I priorities and higher-level objectives of the Horizon Europe Cluster 6 – Food, Bioeconomy, Natural Resources, Agriculture and Environment



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The European Commission envisages nine partnerships under Cluster 6, two of which would be institutionalised (Circular bio-based Europe and EIT Food), four would be either co-programmed or co-funded (Animal Health; A climate-neutral, sustainable and productive Blue Economy; Safe and Sustainable Food Systems for People, Planet and Climate; Water4All), and three would be co-funded (Accelerating Farming System Transition; Agriculture for Data; Rescuing Biodiversity to safeguard life on Earth).

There is seemingly a good balance between the three types of partnerships. However, industry may have some interest in being involved in the design of the Strategic Research and Innovation Agendas regarding living labs and other research infrastructure ('Towards more sustainable Farming' envisaged partnership) to develop solutions for accelerating the transition of farming systems, and technologies to collect agriculture data.

The proposed portfolio of European Partnerships covers the full range of R&I orientations under Cluster 6.

All but one of the proposed partnerships contribute to orienting R&I activities towards the development of food systems that will ensure both sustainable and healthy diets and food and nutrition security for all. The food system has an impact on several challenges. It directly relates to nutrition and diets, access to food, food security, and has an influence on the use of natural resources, water and soil pollution, climate change. Food waste is a key component of circular systems and biomass has strong potential to offer bio-based energy solutions. Finally, the transformation of food systems should take into consideration demographic changes and the accelerating urbanisation (which reduces lands available for food production but offers opportunities for new types of agriculture such as urban farming).

Two R&I orientations are covered by less than half of the proposed partnerships: Environmental Observations (even though achievement in this area could make significant contribution to the other areas) and Bio-based innovation systems (which is nevertheless at the core of the candidate institutionalised partnership for a circular bio-based Europe).

EUROPEAN COMMISSION

Part I. Impact Assessment Studies for the Candidate Institutionalised European Partnerships

8. Candidate Institutionalised European Partnership on Transforming Europe's Rail System

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2020 Directorate-General for Research and Innovation EN

Abstract

This is the final report of the Impact Assessment Study for the candidate Institutionalised European Partnership on Transforming Europe's Rail System under Horizon Europe. The study was conducted by Steer from July to December 2019, under coordination of Technopolis Group. The methodological framework reflects the Better Regulation Guidelines and operationalises the selection criteria for European Partnerships set out in the Horizon Europe Regulation.

This initiative focuses on the development of a pan-European approach to research and innovation in the rail sector. It will address the challenges raised by the lack of alignment of research and innovation with the needs of a competitive rail transport industry and the consequent failure of the European rail network to make its full contribution to European societal objectives. It will also strengthen the competitiveness of the European rail supply industry in global markets. Accordingly, the objectives of the initiative are to ensure a more market-focused approach to research and innovation, improving the competitiveness and modal share of the rail industry and enhancing its contribution to environmental sustainability as well as economic and social development across the European Union.

The study concluded that an institutionalised partnership is the preferred option for the implementation of this initiative.

Executive Summary

This is the final report of the Impact Assessment Study for the candidate Institutionalised European Partnership on Transforming Europe's Rail System under Horizon Europe, conducted by Steer between July and December 2019 under coordination of Technopolis Group. The methodological framework, described in the report on the overarching context to the impact assessment studies, reflects the Better Regulation Guidelines and operationalises the selection criteria for European Partnerships set out in the Horizon Europe Regulation. This report contains the findings of this specific study.

Transforming Europe's Rail System will strengthen the planning, delivery and take-up of research and innovation (R&I) in the European rail sector. It will build on the support provided under Horizon 2020, in particular the work of the Shift2Rail Joint Undertaking (S2R JU) to transform rail services through research as well as development and demonstration of innovative technical solutions.

The initiative must address various challenges for the transport sector, not least the priorities underpinning the European Green Deal, which will require a substantial reduction in greenhouse gas emissions from transport based partly on modal shift from road and aviation to rail. This will need a step change in the competitiveness of rail services, driven by innovations that substantially improve their quality and efficiency. In addition, the rail sector has a key role to play in improving the quality of life of Europe's citizens, including the increasing numbers facing growing road congestion and pollution in cities as well as those in remote areas who rely on public transport. These issues must be addressed against a background of ongoing technological change in transport and the growth of competition in global markets from suppliers in China and other third countries.

Given these challenges, the initiative must meet a number of objectives. First, it must enhance rail's contribution to societal development in Europe by supporting the realisation of the European Green Deal, a people-centred economy and a number of sustainable development goals. Second, it must ensure that rail-related R&I is aligned with market needs, such that innovation materially improves the quality and value for money of rail passenger and freight services. Third, it must strengthen the European RSI's technological lead in world markets. Meeting these objectives will require a long term strategy for R&I, encompassing a wide range of technological developments, drawing on the capabilities and resources of stakeholders inside and outside the rail sector and exploiting synergies with other European initiatives.

In view of the need for private sector participation in the initiative, we have focused on open calls, a co-programmed partnership and an institutionalised partnership under Article 187 of TFEU as possible vehicles for implementation. We have concluded that an institutionalised partnership, able to build on the work of the S2RJU, is the preferred option. Such a partnership would have dedicated resources capable of developing a long term strategy while providing the stable legal and financial framework needed to encourage participation and commitment from a range of public and private stakeholders. It would also give a voice to the European rail R&I community, maintaining a dialogue with European institutions, Member States, regulatory bodies and representatives of third countries able to provide the European RSI with access to new markets.

Résumé exécutif

Ce document est le rapport final de l'étude de support à l'analyse d'impact de la proposition de partenariat européen institutionnalisé pour la transformation du système ferroviaire européen dans le cadre d'Horizon Europe, menée par Steer et coordonnée par Technopolis entre juillet et décembre 2019. Le cadre méthodologique de cette étude, décrit dans le rapport sur le contexte général des études de support aux analyses d'impact, tient compte des lignes directrices pour une meilleure réglementation et opérationnalise les critères de sélection des partenariats européens définis dans le règlement d'Horizon Europe. Le présent rapport contient les résultats spécifiques à cette étude.

La transformation du système ferroviaire européen renforcera la planification, l'exécution et la diffusion de la recherche et de l'innovation (R&I) dans le secteur ferroviaire européen. Elle tirera parti de l'aide fournie dans le cadre d'Horizon 2020, et en particulier du travail de l'entreprise commune Shift2Rail (JU S2R) visant à transformer les services ferroviaires grâce à la recherche ainsi qu'à l'élaboration et à la démonstration de solutions techniques innovantes.

L'initiative doit relever plusieurs défis dans le secteur des transports, surtout les priorités sous-jacentes au Pacte vert pour l'Europe, qui nécessitera une réduction drastique des émissions de gaz à effet de serre issues du transport en partie grâce à un transfert modal de la route et de l'aviation au rail. Un changement radical dans la compétitivité des service ferroviaires devra avoir lieu grâce à des innovations qui amélioreront de manière significative leur qualité et leur efficacité. Par ailleurs, le secteur ferroviaire a un rôle essentiel à jouer dans l'amélioration de la qualité de vie des citoyens européens, notamment pour le nombre croissant de ceux qui doivent faire face à une augmentation du trafic routier et de la pollution dans les villes, mais également dans des endroits reculés dépendants du transport public. Ces problématiques doivent être réglées dans un contexte de changement technologique perpétuel dans le secteur des transports et d'intensification de la concurrence sur les marchés mondiaux par des fournisseurs en Chine et dans d'autres pays tiers.

Compte tenu de ces problématiques, l'initiative doit atteindre toute une série d'objectifs. Tout d'abord, elle doit augmenter la contribution du rail au développement sociétal en Europe en soutenant la mise en œuvre du Pacte vert pour l'Europe, d'une économie à dimension humaine et d'un certain nombre d'objectifs de développement durable. Deuxièmement, elle doit veiller à ce que la R&I dans le domaine ferroviaire soit conforme aux besoins du marché, de sorte que l'innovation puisse améliorer concrètement la qualité et le rapport qualité-prix des services ferroviaires voyageurs et de fret. Troisièmement, elle doit renforcer l'avance technologique de l'industrie européenne de l'équipement ferroviaire sur les marchés mondiaux. Pour atteindre ces objectifs, une stratégie à long terme pour la R&I sera nécessaire, prévoyant toute une série de développements technologiques, s'appuyant sur les capacités et les ressources des parties prenantes internes et externes au secteur ferroviaire et exploitant les synergies avec d'autres initiatives européennes.

Vu que la participation du secteur privé est indispensable à cette initiative, nous nous sommes concentrés sur les appels ouverts à projets, les partenariats co-programmés et les partenariats institutionnalisés au titre de l'article 187 du TFUE comme véhicules potentiels de mise en œuvre. Nous en avons conclu qu'un partenariat institutionnalisé, capable de tirer parti du travail de du JU S2R, était la meilleure option. Ce type de partenariat disposera de ressources dédiées capables d'élaborer une stratégie à long terme, tout en établissant un cadre légal et financier stable nécessaire pour encourager la participation et l'engagement de toute une série d'intervenants publics et privés. Il permettra également de faire entendre la voix de la communauté européenne de R&I ferroviaire, en maintenant le dialogue avec les institutions européennes, les États

membres, les organismes réglementaires et les représentants de pays tiers capables de fournir à l'industrie européenne de l'équipement ferroviaire un accès aux nouveaux marchés.

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Glossary

Article 185	Article 185 of the Treaty on the Functioning of the European Union (TFEU). It covers public-public partnerships, with participation of the EU in research and development programmes undertaken by several EU countries
Article 187	Article 187 of the Treaty on the Functioning of the European Union (TFEU). It covers public-private partnerships, typically involving the EU, industrial association(s) and other partners. These partnerships are managed by legal entities called joint undertakings which are responsible for implementing the research agenda in the area they cover
CER	An organisation representing the interests of European railway operators and infrastructure managers
ERA	European Union Agency for Railways
ERRAC	European Rail Research Advisory Council
ERTMS	European Rail Traffic Management System
Fourth Railway Package	A set of six legislative texts designed to complete the Single European Railway Area ('Technical pillar': Regulation 2016/796 and repealing Regulation 881/2004, Directive 2016/797 and Directive 2016/798; 'Market pillar': Regulation 2016/2338, Directive 2016/2370 and Regulation 2016/2337)
Horizon 2020	European Union Research and Innovation programme covering the period 2014-2020
Horizon Europe	European Commission's proposed programme for Research and Innovation to succeed Horizon 2020, for the period 2021 to 2027
Joint Undertaking	Legal entity defined in the Article 187 of the Treaty on the Functioning of the European Union (TFEU) which is responsible for implementing the research agenda in the area it covers. It typically involves a public-private partnership between the European Union, industrial association(s) and other partners.
MAAP	Multi Annual Action Plan
Master Plan	Agreed roadmap that connects the Research and Innovation activities with deployment scenarios to achieve performance objectives
Member States	Each of the countries party to the European Union founding treaties and subject to the privileges and obligations of membership
R&I	Research and Innovation

RSI	Rail Supply Industry
Regulation 642/2014	Council Regulation (EU) No 642/2014 establishing the Shift2Rail Joint Undertaking
SERA	Single European Rail Area
Shift2Rail JU	The Joint Undertaking (within the meaning of Article 187 of the TFEU) entrusted with the coordination and management of the European Union Research and Innovation activities in the European rail sector
SME	Small and Medium sized Enterprise
TEN-T	Trans-European Transport Network
TRL	Technology Readiness Level, a categorisation of the maturity of a technology during its development
TFEU	Treaty on the Functioning of the European Union
TSI	Technical Specifications for Interoperability
UIC	International Union of Railways (Union Internationale des Chemins de Fer)
UITP	Union Internationale des Transports Publics, an international association of public transport service providers
UNIFE	Association of the European Rail Industry (Union des Industries Ferroviaires Européennes)

1 Introduction: Political and legal context

This document presents the impact assessment of the candidate institutionalised partnership Transforming Europe's Rail System, which is one of the initiatives that will enable implementation of the Commission's vision for the period beyond 2020 under the Horizon Europe Pillar II, specifically the Climate, Energy and Mobility Cluster. It is one of the envisaged European Partnerships in the Transport Partnership Area.

1.1 Emerging challenges in the field

The European rail sector faces a number of challenges, including the development of new technologies affecting the broader transport sector and changes in its key markets, the latter reflecting both technological development and societal trends such as the increasing urbanisation of the population and associated changes in travel patterns. A fuller discussion is included in Appendix D. However, the rail transport industry has often struggled to respond effectively to these challenges and remains relatively uncompetitive compared to road transport and other modes, notwithstanding substantial progress in creating a Single European Railway Area (SERA) and access to an indigenous rail supply industry (RSI) enjoying a technological lead in global markets.

This means that the European rail sector, broadly defined, has yet to demonstrate its full potential to support key European policy goals. In particular:

- While rail transport results in considerably lower environmental emissions than road transport or aviation, realising its full contribution to the European Green Deal will depend on the ability of rail services to secure a significantly higher share of both passenger and freight transport markets than at present. This, in turn, will require a step change in both the efficiency and quality of international, national, regional and local rail services.
- Rail also has a role to play in improving connectivity for Europe's citizens, increasing journey opportunities for the rising proportion of the continent's population living in cities as well as those in rural and other communities who continue to depend on public transport. This will require better integration of different transport modes, including through collective transport solutions that combine traditional public transport with new services such as car-pooling and flexible mobility.
- As well as addressing both these challenges more effectively, the rail sector must continue to support the sustainable development and better integration of the European economy. While the completion of SERA and the further enhancement of high speed and conventional networks through TEN-T and other initiatives will substantially improve connectivity between Member States and with third countries, rail operators and infrastructure managers will need to respond positively to new opportunities to improve the attractiveness of rail travel through continuous innovation.

The table below summarises the broader trends and challenges facing the rail sector, drawing on the evidence presented in Appendix D. Taken together, they have important implications for both the direction and organisation of rail-related research and innovation (R&I), as discussed throughout this report.

Table 1: Overview of the challenges emerging

Challenge	Observed trends and issues
Social	The widespread use of new technology to enable travel planning is changing the competitive landscape for transport with, for example, concepts such as car sharing and mobility as a service (MaaS) providing individuals with a wider choice of travel options. More

Challenge	Observed trends and issues
	generally, the need for private vehicles, particularly in large cities, is reducing. At the same time, there is increasing demand for efficient transport solutions within urban areas as populations are increasingly located in cities. In addition, the ageing of populations across Europe is placing new demands on public transport, for example in terms of accessibility and security of services.
Technical and technological	New technologies being applied in the automotive sector have the potential to undermine the traditional advantages of rail travel, although they also provide opportunities for improving rail transport. New technological developments should enable substantial increases in rail sector efficiency, for example by enabling more efficient use of infrastructure and reducing energy consumption. Developments in retailing, in particular the substantial growth in internet purchases, are driving changes in the logistics market with, for example, the share of on-demand freight services increasing relative to more conventional distribution.
Competitiveness	While the demand for rail passenger services in Europe has increased steadily over the last ten years, growth has been limited and insufficient to challenge the dominance of the private car. In the case of freight, demand has been flat overall and has not yet fully recovered from the substantial decline caused by the 2009 economic recession. The modal share of both passenger and rail freight services has changed little, notwithstanding the introduction of successive policy initiatives at the European level designed to increase the competitiveness of rail transport. At the same time, the leadership of the European rail supply industry in global markets is increasingly threatened by the growth of suppliers in China and elsewhere in Asia. The development of the Chinese industry, supported by substantial R&I investment and promotion of exports through Chinese government support to developing countries, has been particularly marked.
Environmental	Rail continues to have a substantial advantage over other transport modes in terms of its impact on the environment, which should enable it to play a major role in delivering the European Green Deal announced by the new President of the European Commission. The rail industry has achieved a steady and substantial reduction in greenhouse gas emissions, and emissions per unit continue to be significantly below those recorded by aviation and road transport. However, given that rail's share of both passenger and freight markets has remained relatively stable over many years, to date it has not been possible to fully realise its potential contribution to reducing the environmental impacts of transport. Increasing environmental awareness among EU citizens, partly generated by Extinction Rebellion and other movements, may help to address this but significant change in travel behaviour will depend on improving the attractiveness or rail services.
Political, policy and regulatory framework	There has been substantial progress in the completion of SERA, with the adoption of the Fourth Railway Package completing a process of industry restructuring and liberalisation begun almost 30 years ago.

Challenge	Observed trends and issues
	Nevertheless, substantial work remains to be done in harmonisation of technical standards and operational practice.

There was strong support among stakeholders responding to the **open public consultation (OPC)** for aligning the direction of R&I under Horizon Europe with key European policy objectives, in particular decarbonisation of the European economy. A substantial majority of business organisations (both large organisations and SMEs), business associations, academic and research institutions, public authorities and EU citizens considered that any future European Partnership should respond effectively to European policy goals. A majority of these groups also confirmed the importance of meeting societal needs and contributing to Sustainable Development Goals while supporting EU global competitiveness. There was particularly strong support among EU citizens and public authorities for a partnership that would contribute to achieving EU climate-related goals.

The **stakeholders interviewed** were generally supportive of the objectives of the existing S2R JU, which include aims relating to the completion of SERA and a reduction in environmental emissions as well as broader societal goals, and considered them to be relevant for any future partnership. Some also proposed additional objectives focused on specific issues, for example better integration of transport modes to enable greater door-to-door mobility, a greater focus on interoperability and network efficiency and the acceleration of market take-up of innovation. The ongoing importance of improving the attractiveness of rail freight to enable it to compete more effectively with road transport was a strong theme in many interviews, in particular those with representatives of train operators, infrastructure managers and the RSI.

Several stakeholders providing **feedback on the inception impact assessment** for the candidate partnership, including large and small business organisations and an academic and research institution, confirmed the importance of rail-related R&I in enhancing the role of rail in an integrated and sustainable European transport system. Several EU citizens also provided feedback, noting the potential for rail to compete for passengers currently using air transport through easier planning of journeys using several modes, more competitive journey times, better management of service disruption and higher quality on-board service, all of which would depend on the application of new technology. One also highlighted the importance of using technology to improve the attractiveness of rail freight services and reduce the volume of freight traffic using road transport.

1.2 EU relative positioning

1.2.1 Competitive positioning of Europe in the field

The European RSI has been highly competitive in global markets over many years, and its technological leadership has been strengthened considerably by various EU policy initiatives, notably the European Railway Traffic Management System (ERTMS). The RSI is comprised of some 4,500 enterprises, directly employing around 400,000 people and indirectly supporting more than 1.2 million jobs,[1] and its annual turnover in 2017 has been at around €49 billion.[2] According to UNIFE, a body representing the RSI in Europe, it

[1] European Commission (2019a), Final report of the expert group on competitiveness of the European rail supply industry, October 2019, available at: https://ec.europa.eu/docsroom/documents/37829.

[2] European Commission (2019b), Study on the competitiveness of the Rail Supply Industry, Ecorys, September 2019, available at: https://ec.europa.eu/docsroom/documents/38025.

accounted for 46% of a world supply market estimated by to be worth some €163.2 billion per year in the same year.[3]

The RSI is a major exporter of rail equipment, for example exporting €4.8 billion of locomotive and rolling stock products in 2017 compared with €2.3 billion exported by China and a similar value by the US. In the same year, the European RSI accounted for 80% or more of signalling and electrification equipment imported by China, Japan and Russia.[4] These efforts have been bolstered by ERTMS, which has been adopted as a train control system in many countries outside Europe including Argentina, China, India, South Korea and Taiwan. In its World Rail Market Study 2018, UNIFE reported that the European Train Control System (ETCS) was either in operation or contracted for installation on 96,000 km of track, and that some 13,000 vehicles were either already equipped or due to be equipped with related on-board units.[5]

However, the European RSI's competitive position has been increasingly challenged by suppliers based in Asia, and particularly China, over several years, not least because of their substantial investment in R&I and support provided by their respective national governments. In the impact assessment accompanying the proposal to establish the Shift2Rail Joint Undertaking (S2R JU), the Commission reported that R&D expenditure by China Railway and China Railway Construction amounted to some $1.5 billion in 2011 (expressed in 2005 prices).[6] More recently, a study of the competitiveness of the European RSI, undertaken by Ecorys on behalf of the Commission, noted that China is now the leading producer of high-speed trains, electric locomotives and metro cars and that its growing strength in export markets is actively encouraged through the Chinese government's support for infrastructure investment in developing countries.[7]

These concerns are reinforced by increasing complaints from European suppliers that they are being excluded from rail product markets in China. Several companies have reported an increasing tendency for Chinese cities to support local suppliers as part of a broader strategy to build the capability of the Chinese industry, for example through procurement processes that explicitly score down bidding entities relying on foreign investment. Concerns have also been expressed that China's Belt and Road Initiative (BRI), a major programme of investment to build a network of rail and other transport links between China, Europe and other regions, is as much a vehicle for developing Chinese suppliers of rail equipment as it is a plan to facilitate trade flows.[8] More generally, a perceived imbalance in the openness of Europe's rail market compared to that in other countries has

[3] UNIFE (2018), World Rail Market Study, September 2018, summary available at: http://www.unife.org/publication-press/publications/158-world-rail-market-study-executive-summary-2018.html. Note that the UNIFE study considers a broader definition of the market than the European Commisison study on competitiveness and the data taken from each source do not therefore reconcile.

[4] European Commission (2019b), op. cit.

[5] See UNIFE (2018), op. cit.

[6] European Commission (2013), Impact Assessment accompanying the document: Proposal for a Council Regulation establishing the Shift2Rail Joint Undertaking, 16 December 2013, available at: https://shift2rail.org/wp-content/uploads/2013/07/IMPACT-ASSESSMENT-Accompanying-the-document-Proposal-for-a-Council-Regulation-establishing-the-Shift2Rail-Joint-Undertaking.pdf.

[7] See European Commission (2019b), op. cit.

[8] See European Parliament (2018), Research for TRAN Committee: The new Silk Route – opportunities and challenges for EU transport, January 2018, available at: http://www.europarl.europa.eu/RegData/etudes/STUD/2018/585907/IPOL_STU(2018)585907_EN.pdf.

prompted the Commission to explore ways of stemming unfair competitive practices and of providing support to European firms struggling to access global markets.[9]

Against this background, the ongoing competitiveness of the European RSI will be particularly dependent on its ability to undertake rail-related research and leverage the benefits of the resulting technological development through rapid innovation. As the initial impact assessment for the S2R JU highlighted, this, in turn, will depend on ongoing, large scale and coordinated investment in R&I.

1.2.2 Support for the field in the previous Framework Programme

The S2R JU was established under Council Regulation 642/2014 to strengthen the role of rail in the European transport system through more effective sponsorship and management of the sector's R&I effort. It administers an extensive programme of R&I activity, aligned with the delivery of a series of major operational and technological innovations set out in its Master Plan and further elaborated in a detailed Multi-Annual Action Plan (MAAP). The organisation and governance of the S2R JU is described in Appendix D.

Under the provisions of the Regulation, the total funding available to the JU under Horizon 2020 was €920 million, including:

- A contribution from the European Commission of €450 million, representing a substantial increase in funding of €155 million made available under Framework Programme 7 (FP 7);
- Contributions from industry, including both in-kind contributions to operational activity and financial contributions to administrative costs, totalling €350 million (€200 million from founding members and €150 million from associate members); and
- Further in-kind contributions from industry of €120 million in support of additional activities.

The scope of the additional activities is at the discretion of the members and the JU does not provide direct support, although it does confirm that the activities have been undertaken and that the associated resources have been allocated accordingly. The Commission contribution to overall resourcing includes €100 million allocated to open calls, the funding of which is not supported by members.

The activity overseen by the JU represents a substantial contribution to the R&I effort of the European RSI. In 2014 UNIFE estimated that the industry invested 2.7% of annual turnover (equivalent to some €780 million) in R&I. This is comparable in relative terms to some sectors but substantially below that in others, for example the 6% invested by the aerospace and defence industry.[10] The relatively low intensity of R&I activity in the rail sector observed before Horizon 2020 was an important factor in building the case for establishing the JU.

The JU's activity is structured around five main Innovation Programmes (IPs) and five Cross Cutting Activities (CCAs), as summarised in Appendix D. The scope and budget of each IP have evolved since its establishment as new issues and priorities have emerged. In addition, a new 'IPx' has been added to reflect structural change in the life of the overall

[9] European Political Strategy Centre (2019), EU Industrial Policy after Siemens-Alstom: Finding a new balance between openness and protection, available at: https://ec.europa.eu/epsc/sites/epsc/files/epsc_industrial-policy.pdf.

[10] UNIFE, European Rail Industry – A driver for EU competitiveness and sustainable mobility worldwide available at: http://www.unife.org/component/attachments/?task=download&id=110.

programme and to enable the development of a functional system architecture for the next generation of railway systems.

Article 2 of Council Regulation 642/2014 specifies several general objectives for the S2R JU:

- To contribute to the implementation of the Horizon 2020 Programme, particularly the Smart, Green and Integrated Transport Challenge under the Societal Challenges element;
- To contribute to the achievement of SERA, to a faster and less costly transition to a more attractive, user-friendly, competitive, efficient and sustainable European rail system, and to support the development of a strong and globally competitive European rail industry;
- To establish, develop and implement a strategic Master Plan;
- To play a major role in rail-related R&I, ensuring a comprehensive and coordinated approach to meeting the R&I needs of the rail system and its users;
- To actively promote the participation and close involvement of all relevant stakeholders from the full rail value chain and from outside the traditional rail industry; and
- To develop demonstration projects in interested Member States, including in those that currently do not have a railway.

Article 2 of the Regulation also identifies various key performance indicators (KPIs) that align with the objectives of the overall policy framework for rail, including a target reduction in the whole-life cost of Europe's rail system as well as target increases in its capacity, punctuality and reliability. These are described in Appendix D.

The JU has been successful in building participation from organisations throughout the rail industry value chain, including infrastructure managers, train operators and a wide range of organisations from the RSI as well as research and educational institutions. The profile of participation tends to reflect the allocation of available Union funding, with 40% allocated to founding members, 30% to associate members and their affiliates and 30% to open calls (in accordance with Article 17 of Annex 1 of the Regulation). Further analysis of stakeholder participation in the JU is presented in Appendix D. Here, we note that:

- The founding members of the JU, including the manufacturers Alstom, Ansaldo STS (now Hitachi), Bombardier, CAF, Siemens and Thales and the infrastructure managers Network Rail and Trafikverket, are major contributors to the work programme, as are the associate members Deutsche Bahn and SNCF.
- Educational as well as scientific and research institutions are well represented, although participation is concentrated on a relatively limited number of organisations such as the KTH Royal Institute of Technology and Deutsches Zentrum für Luft und Raumfahrt (DLR).
- While the interests of rail operators are clearly represented, including by associate members, representation is distributed in favour of major national passenger operators, while freight operators and operators of urban networks are less involved (although organisations such as DB Cargo, Wiener Linien, Metro de Madrid and London Underground have participated in a limited number of projects).

Notwithstanding the progress made since the establishment of the JU, our research has highlighted various issues relevant to the impact assessment of a future initiative under Horizon Europe. Note that while many of these issues are already being addressed through

the implementation of an action plan,[11] the JU itself has emphasised the need to continue to take account of them in shaping future policy. The following table summarises the main issues according to a taxonomy developed by Technopolis.

Table 2: Current issues highlighted by the experience of the S2R JU

Market issues	
Market power	Project participation rates are distributed in favour of a relatively limited number of organisations. While this does not indicate market power in a conventional sense, it could result in an R&I programme that is unduly focused on issues faced in a limited number of Member States.
Systemic failures	
Institutional	The role of the Scientific Committee needs to be strengthened and better aligned with the evolving requirements of the future R&I programme, for example with more representatives able to comment on the specification and delivery of demonstration programmes as distinct from more basic research. Management processes have been relatively rigid, with insufficient communication between IPs leading to inadequate understanding of the direction and results of R&I effort in different parts of the programme. While this issue has been addressed to some degree in an action plan, some stakeholders continue to suggest that interaction between the IPs is limited.
Infrastructural	Certain operational rules determining the participation of different organisations are unduly restrictive. In particular, Horizon 2020 rules requiring the participation of organisations from three different Member States in open calls makes it more difficult to secure the support of individual SMEs and can encourage the involvement of organisations with little to contribute to a particular programme of activity. The administrative burden of the open calls procedure also appears onerous to some stakeholders.
Transformational failures	
Directionality	While the IPs are focused on a number of important areas of research, a more balanced research agenda, taking account of societal and operational issues facing the rail industry and better addressing the needs of urban and freight operators needs to be adopted. One option would be to structure future R&I activity around the concept of 'mega projects', defined by reference to the benefits of new technologies for the whole rail system rather than according to the boundaries of specific sub-systems. In addition, there is a need for greater emphasis on demonstration projects to improve market take-up of R&I outputs. This requires a move towards more R&I programmes at TRL 7-9, a significant change from the focus on

[11] Since the interim evaluation was completed, the S2R JU has sought to address its findings through a range of documented actions, for example enhanced engagement with other JUs, measures to reduce the administrative burden of calls for members and a review of the mandate of the Scientific Committee. See S2R JU (2018), Action Plan in response to the recommendations of the interim evaluation of the Shift2Rail JU, March 2018, available at: https://shift2rail.org/wp-content/uploads/2018/07/Decision-08_2018-Annex_Interim_Action_Plan.pdf.

	TRL 1-6 under Horizon 2020, albeit it one that builds on the greater emphasis on demonstration activity in the latest Multi-Annual Action Plan.
Policy coordination	In the past, there has been insufficient exploitation of synergies between the S2R JU and other JUs, particularly in view of application of key technologies such as digital across the transport sector and more broadly. We understand that a Commission working group has been established to consider the application of technologies such as artificial intelligence and blockchain to transport, and future policy in respect of rail-related R&I will need to be informed by its findings.

1.3 EU policy context beyond 2021

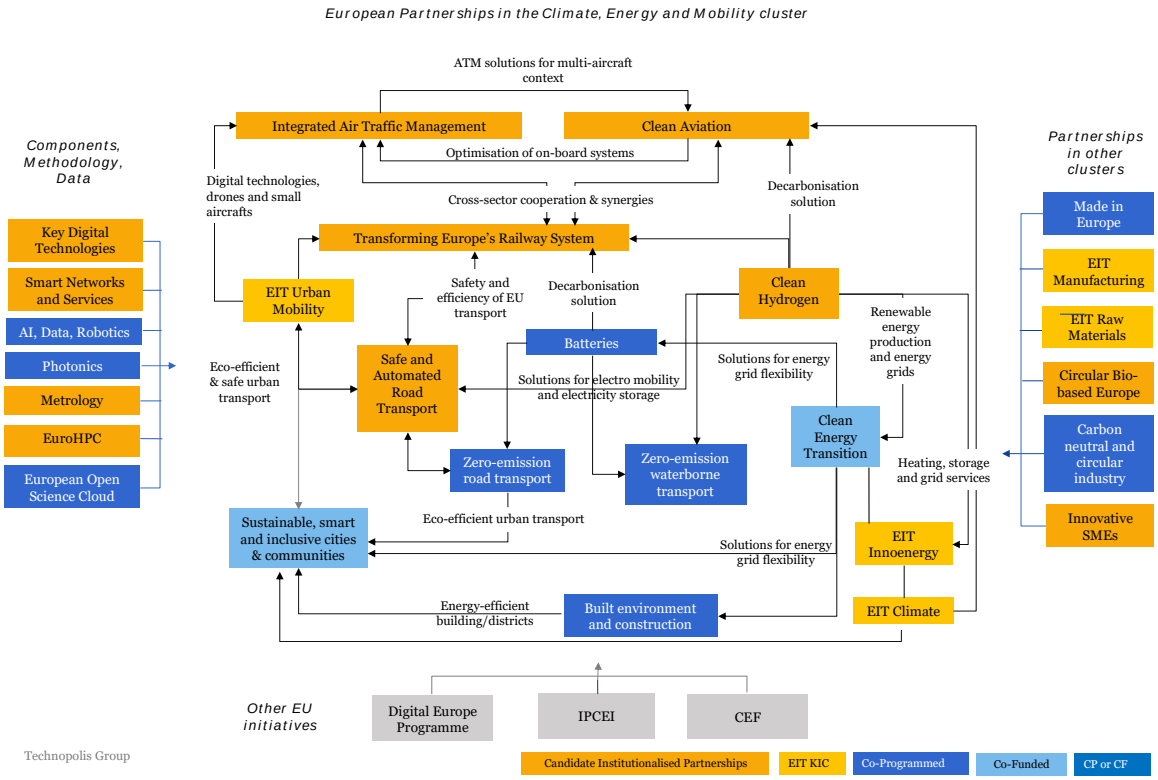
As set out in the report on the overarching context to the impact assessment studies, the R&I activities funded under the Pillar II Cluster Climate, Energy and Mobility are intended to contribute to the attainment of at least three of the six main ambitions for Europe: 'A European Green Deal', 'A People-centred Economy' and 'A Digital Europe'. It is supportive of several of the Sustainable Development Goals, particularly Affordable and Clean Energy (SDG 7), Industry Innovation and Infrastructure (SDG 9), Sustainable Cities and Communities (SDG 11) and Climate Actions (SDG 13).

The candidate partnership for Transforming Europe's Rail System also has the potential to support SDG 3 (Good Health and Well-being), SDG 8 (Decent Work and Economic Growth) and SDG 9 (Industry, Innovation and Infrastructure), not least by enhancing the competitiveness of rail freight (thereby reducing the volume of freight traffic moving by road) and by addressing many of the challenges arising from the increased urbanisation of Europe's population (see Appendix D). It could also contribute significantly to achieving a number of the objectives of European transport and broader environmental policy (also described in Appendix D), in particular by encouraging greater use of rail services and less reliance on modes of transport responsible for higher levels of CO_2 emissions.

There are eight candidate institutionalised partnerships within the Climate, Energy and Mobility cluster. All except the one concerned with 'Mobility and Safety through Automated Road Transport (MOSART)' would build on previous Article 187 initiatives or EIT-KICs funded under Horizon 2020.

A detailed analysis of synergies for the envisaged and candidate partnerships that are related to this cluster is shown in Figure 1. This highlights the five possible Article 187 partnerships and the synergies between them and with other partnerships. Four can be considered as 'application' sector partnerships while the fifth (clean hydrogen) is more technology-orientated. The central position of batteries and hydrogen as enablers of zero emission transport and the clean energy transition is also clear from the analysis. Likewise, there are synergies with the other technology-related partnerships, particularly in the digital area, and those that are manufacturing or materials-orientated. This also highlights the twin challenges of digitisation and decarbonisation for the future energy/mobility sectors. Finally, the European Open Science Cloud partnership will provide 'horizontal' (infrastructural) support to collaborative research and innovation within each envisaged partnership in Cluster 5, while also facilitating exchange and re-use of research data for the integration of new technologies into energy and mobility solutions.

Figure 1: Interconnections between the envisaged partnerships in the Climate, Energy and Mobility cluster



There would appear to be many areas for collaboration between the candidate partnerships and across clusters. A good example of coordination and consolidation of partnerships from Horizon 2020 is 'Clean Energy Transition', which builds on 10 separate ERA-NET Co-fund actions that have synergy with the SET-Plan. These are primarily related to renewable energy technologies (e.g. solar, wind, geothermal, marine and biotechnology) and smart grids, which are needed to address the increasing proportion of distributed renewables in the energy mix. This is one of only two proposed co-funded partnerships (CF) in this cluster (the other being 'sustainable, smart and inclusive cities and communities') that would involve the national R&I funding organisations. The others (A187/CP/EIT-KIC) are primarily driven by industrial and research stakeholders.

There is less evidence of coordination and consolidation among the mobility-related partnerships. For example, there is a lack of a cross-modal perspective across the four prospective A187/CP partnerships as their titles imply different objectives and stakeholders. There are, however, several areas where there is likely to be scope for collaboration. These include the following:

- 'Integrated Air Traffic Management' will have an influence on 'Clean Aviation' but also has wider objectives related to the EU priority of 'an economy that works for people'.
- 'Safe and Automated Road Transport' and 'Zero-emission Road Transport' have some common industry stakeholders (i.e. the vehicle industry) but one is orientated towards the digital industries and the other towards the energy industries.
- 'Zero-emission Road Transport' and 'Zero-emission Waterborne Transport' have supply chain synergies and challenges, particularly in relation to heavier duty applications.

This suggests that the more recent candidate co-funded partnership on 'Sustainable, Smart and Inclusive Cities & Communities' could play a strategic role in fostering cross-modal activities and encouraging collaboration. In the case of the Transforming Europe's Rail System, we would also anticipate scope for joint programming of R&I activity with the Key Digital Technologies partnership, recognising the likely pervasive impact of such

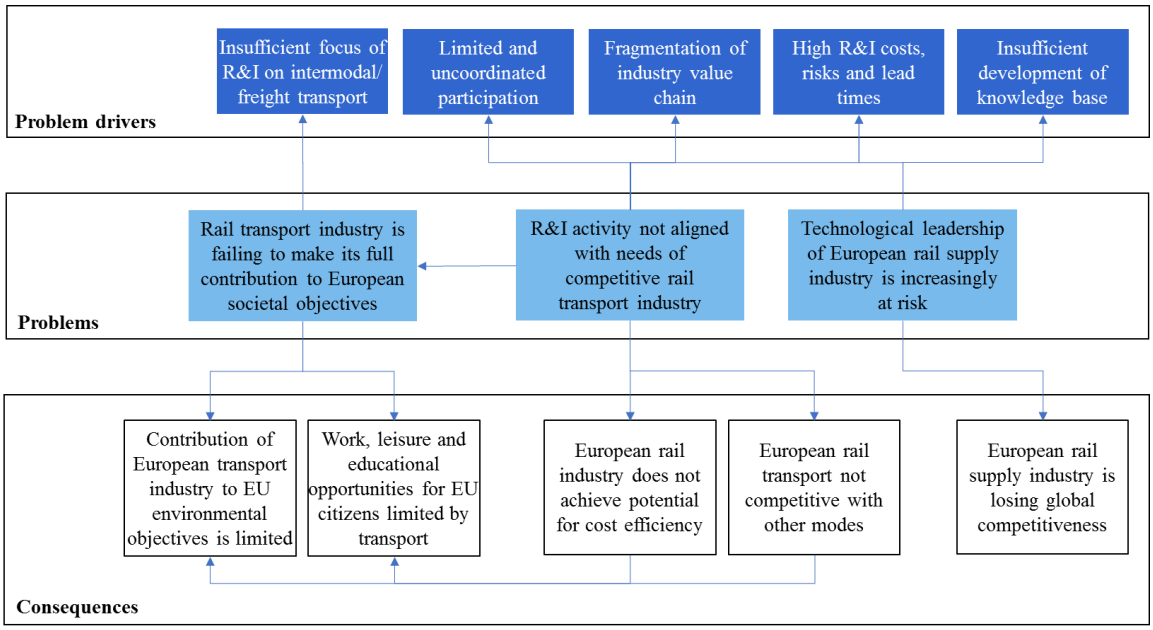
technology on the rail sector (see Appendix D) and the Batteries partnership, recognising the potential for greater use of battery and fuel cell technology to reduce the need for investment in electrification of rail infrastructure.

A further question concerns the extent to which the national/regional R&I funding agencies would be prepared to participate directly in A187/CP projects, as this could enable better commercial links between projects at lower Technology Readiness Levels (TRLs) funded by the public sector and encourage greater market focus in the design and delivery of projects.

2 Problem definition

This section provides a discussion of the problems to be addressed in relation to the emerging challenges presented in *Section 1.1*, drawing on evidence from desk research and the findings of the stakeholder consultation undertaken as part of this study. A problem tree portraying related problems, their drivers and consequences is presented in Figure 2 and described in detail in the following sections.

Figure 2: Problem tree for the initiative for Transforming Europe's Rail System



2.1 What are the problems?

Note that as the baseline for the impact assessment is defined as collaborative research under Horizon Europe (i.e. the absence of a JU or any other type of partnership), an examination of the situation prevailing before the existing JU was established, when rail-related R&I activity was similarly supported purely through open calls, appears relevant. We have therefore sought to investigate issues arising during FP7 and before, while recognising that aspects of the policy pursued under Horizon 2020 may have had a long-lasting impact on rail-related R&I activity in Europe and hence on the problem to be addressed by any future initiative.

2.1.1 Contribution to European societal objectives

As noted in *Table 1* and discussed more fully in Appendix D, the rail transport industry (including heavy rail, tram and metro services) has failed to increase its share of European passenger and freight markets materially over a period of more than 10 years. In addition, users of rail services continue to express dissatisfaction with train frequency and

punctuality as well as other aspects of the service.[12] This means that rail has yet to make its full contribution to the achievement of European societal objectives.[13]

- Without significant changes to modal share, rail cannot make a full contribution to the required reduction in greenhouse gas emissions, although increasing electrification and fuel efficiency can be expected to reduce emissions per passenger-km and per tonne-km.
- Similarly, progress in addressing the challenges arising from increased urbanisation, including congestion and poor air quality, has been limited, reducing the quality of urban living (see Appendix C). Given the trend towards urbanisation, this can be expected to affect a much higher proportion of the European population, possibly as much as 84% by 2030.[14]
- More generally, further integration of national rail networks with urban transport systems and other modes of transport have proceeded on a piecemeal basis, constraining improvements in connectivity that could provide European citizens with access to enhanced work, education and leisure opportunities.

While these failures are attributable to a range of factors, including transport policy priorities at the local, national and European levels, limited availability of funding for transport investment and ongoing operational challenges faced by Europe's rail service providers, they partly reflect the scope of R&I under previous Framework Programmes, as discussed further in *Section 2.2.1*.

2.1.2 Needs of a competitive rail transport industry

The failure of the rail transport industry to compete effectively against other modes of transport reflects both the persistence of inefficiency, contributing to relatively high fares and/or excessive calls on public funding, and a lack of innovation. Both these issues will need to be addressed if rail transport is to materially increase its share of transport markets, a key requirement in unlocking its potential contribution to meeting societal objectives.

However, experience under FP7 and previous Framework Programmes suggests that the European RSI supported by open calls alone would be unlikely to undertake the level and scope of R&I activity required to materially improve the competitive position of the rail transport industry. The impact assessment accompanying the proposal to establish the S2R JU noted that R&I efforts under previous Framework Programmes had not been sufficiently targeted towards the completion of SERA, notwithstanding that the creation of a large internal market for rail products might have been expected to increase the competitiveness of European rail services.

In our view, this analysis of the problem remains valid. The completion of SERA will continue to depend, inter alia, on the removal of technical barriers to the establishment of a genuinely pan-European rail network, achieved in part through the closing out of open points under TSIs and the identification of common technical solutions to issues previously addressed at the national level. More generally, rail-related R&I will only support a material change in rail's share of passenger and freight traffic if it produces outputs supporting the development of a fully integrated European rail system that can be taken up by

[12] European Commission (2018), Flash Eurobarometer 463: Europeans' satisfaction with passenger rail services, available at: https://data.europa.eu/euodp/en/data/dataset/S2172__ENG.

[13] See *Appendix D* for a discussion of relevant European policy initiatives defining various societal objectives.

[14] See United Nations Population Division, World Urbanisation Prospects 2018, available at: https://population.un.org/wup/Download/.

infrastructure managers, train operators and others engaged in the provision of rail services. This will require greater focus on market needs than has been apparent previously, at least before Horizon 2020, and the participation of stakeholders capable of both validating the specification of R&I projects and supporting the demonstration of their value to the market. The evidence on stakeholder participation and market take-up is discussed in *Sections 2.2.2* and *2.2.3* respectively.

2.1.3 Technological leadership of the European RSI

We have already noted in *Section 1.2.1* the view within the RSI and among policy makers that the industry's market leadership is increasingly under threat. The recent report of the expert group on the RSI's competitiveness noted that, notwithstanding key strengths such as its historic technological leadership, a skilled workforce and well-established supply chains, the industry faces several major challenges.[15] In the context of this study, the following are particularly important:

- If it is to embrace the new technologies on which both its position in global markets and the attractiveness of rail transport services in Europe depend, the RSI will require new skills. However, in common with other sectors it is facing difficulties in recruiting skilled staff in engineering and information technology, compounded by job market competition and an ageing population.
- While specialised SMEs continue to play a key role within the industry, exploiting their greater flexibility to bring innovation to the market more quickly than larger, less agile firms, their ability to access international markets is often limited. This is because they typically lack the resources needed to secure market access (e.g. to ensure compliance with relevant legislation) and face difficulties in obtaining finance.
- The RSI's competitive position relies critically on the protection of intellectual property rights, with many organisations within the industry holding registered industrial designs and patents that support their technological leadership in the market. The ongoing success of the industry will therefore continue to depend on its ability to both generate and enforce intellectual property in competition with its counterparts in third countries.

While the problem of erosion of the European RSI's technological leadership raises issues that go beyond R&I activity, it is nevertheless partly a reflection of the level and direction of R&I effort under previous Framework Programmes, as discussed in *Section 2.2.5*.

Many of the stakeholders responding to the **OPC** confirmed the importance of these issues. A substantial majority of business organisations, business associations, academic and research institutions, public authorities and EU citizens considered that the need to strengthen the role of rail in the transport system through R&I was very relevant, and support for improving the competitiveness and attractiveness of rail services was also strong among all these groups. Moreover, as noted in *Section 1*, stakeholders also identified the importance of aligning R&I under Horizon Europe with EU societal objectives, in particular climate-related objectives. At the same time, there was strong support for common action to advance key technologies and radically transform rail, particularly from larger business organisations and public authorities.

These themes were echoed during the **interview programme**, with several stakeholders highlighting the lack of competitiveness of rail transport in Europe and the increasing challenge to the RSI's position in global markets. There was a consensus among representatives of the RSI as well as train operators and infrastructure managers that rail

[15] See European Commission (2019a), op. cit.

could make a much greater contribution to the achievement of European societal objectives through a step change in its competitiveness and better integration with other modes.

As previously noted, several of the stakeholders providing **feedback on the inception impact assessment** highlighted the importance of improving the attractiveness of rail transport from the perspective of both passengers and freight customers, and the need to better integrate rail services with the wider European transport system to improve connectivity for EU citizens and meet other societal goals. Some, including an academic and research institution and a large business organisation also stressed the importance of reinforcing Europe's technological leadership in rail.

2.2 What are the problem drivers?

The key problem drivers affecting R&I performance in the rail sector are discussed in more detail in the following paragraphs and summarised according to a standard taxonomy in *Appendix D*. We have identified five problem drivers that will need to be addressed by any future initiative on rail-related R&I under Horizon Europe.

2.2.1 Insufficient focus of R&I on intermodal and freight transport

We have already noted that the rail transport industry must increase its share of freight traffic, respond to the increasing urbanisation of Europe's population and provide greater connectivity within and between Member States if it is to contribute fully to the societal objectives identified in successive European policy initiatives. This will require, inter alia, the adoption of technical solutions supporting the development of a more competitive rail freight offer and enabling more passenger-friendly transport services based on better integration of different transport modes, including within cities. Developments of this kind have the potential to substantially reduce road congestion as well as pollution and greenhouse gas emissions generated by road traffic.

However, to date the contribution of rail-related R&I to achieving these objectives has been limited. For example, of 87 projects funded under previous Framework Programmes and recently evaluated by Foster Rail on behalf of ERRAC (see *Appendix D*),[16] we identified only 14 explicitly concerning freight, of which only two were considered to have resulted in strong market take-up. The corresponding numbers for urban transport were 17 and three.

These findings align with those of the impact assessment accompanying the proposal for the S2R JU[17], which noted that transport and freight operators were involved in less than 10% of transport projects supported under FP5 and FP6 "despite their participation being essential to achieving integrated rail system solutions that fit with market needs". Note also that while the S2R JU has succeeded in increasing the level of R&I effort focused on rail freight, there could be no guarantee that this would be sustained under a framework of support relying entirely on open calls. Moreover, given the difficulties of securing the participation of key stakeholders such as rail freight and urban transport operators, discussed further in the following section, we suggest that the lack of focus on both freight and urban transport markets evident before Horizon 2020 would be likely to re-emerge under the baseline scenario.

2.2.2 Limited and uncoordinated participation

The impact assessment accompanying the proposal for the S2R JU reported varying degrees of participation in R&I activity among different stakeholders during preceding Framework Programmes. Before Horizon 2020, competitive calls for research proposals led

[16] Foster Rail (on behalf of ERRAC) (2016), Evaluation of finalised projects with clear understanding of the market uptake mechanism, May 2016

[17] See footnote 6.

to the formation of ad hoc consortia and the specification of projects that were not necessarily well-aligned with EU policy objectives. Moreover, consortia frequently failed to include passenger and freight operators, notwithstanding the need to ensure that R&I activity took account of market needs.

The stakeholder consultation undertaken as part of this study tends to confirm the importance of more active participation from a range of stakeholders, bringing different capabilities and a balance of perspectives. Table 37 in *Appendix D* summarises the main types of stakeholder that can contribute to R&I effort, the nature of the contribution and the potential constraints affecting their participation in collaborative R&I. This summary, while not comprehensive, demonstrates the range of capabilities and constraints that need to be accommodated within an overall collaborative effort to progress relevant R&I activity. While each group has a key contribution to make, the different incentives and constraints that they face means that, operating in isolation, they may be unwilling or unable to combine in ways that maximise the efficiency and effectiveness of available R&I resources.

By way of illustration, the Framework Programmes preceding Horizon 2020 achieved only limited success in leveraging private sector participation in R&I activity. The impact assessment accompanying the proposal to establish the S2R JU reported an average share of private sector funding for the FP7-Transport budget line of only 34%, and only three projects obtained more than a 40% contribution from private sector participants. In addition, only 28% of rail projects funded under FP7-Transport were coordinated by private companies compared to 43% coordinated by university and other research organisations. This resulted in greater emphasis on projects targeting relatively low TRLs (pre-competitive research at TRL 1-3) rather than development and demonstration projects (TRL 4-7).

2.2.3 Fragmentation of the industry value chain

There are various dimensions to the fragmentation of the European rail industry that must be considered in the formulation of policy objectives and the assessment of policy options for Horizon Europe. These interact to undermine the coordination of R&I effort, potentially resulting in research activity that is both too limited and too misdirected to materially improve the competitive prospects of both European rail transport and the RSI.

First, notwithstanding the work of ERA and the development of TSIs, the European rail network consists of a variety of different national and regional systems constructed and operating to different technical standards. For example, there are currently some 14 different signalling systems in operation across Europe and, given the costs and risks involved, coordination of the necessary R&I activity needed to establish an agreed common standard by industry actors and individual Member States alone would be at best highly challenging.

ERA's report on "Railway Safety and Interoperability in the EU 2018" provides further illustration of the level of technical and operational fragmentation of the rail network in terms of several different metrics.[18] For example, the report notes that by May 2018 only 9% of the TEN-T Core Network Corridors had been equipped with ETCS although the corresponding level of deployment of the Global System for Mobile Communications – Railway (GSM-R) was 57%. The 9% deployment level for ETCS compares with an intermediate target level of 31% by 2023, suggesting a significant challenge in replacing legacy train control systems as compared with original expectations. The report also noted significant numbers of requested derogations from TSIs related to fixed installations,

[18] European Union Agency for Railways (2018), Report on Railway Safety and Interoperability in the EU, 2018 available at: https://www.era.europa.eu/library/corporate-publications/safety-and-interoperability-progress-reports_en.

indicating the persistence of technical barriers for vehicles (which must comply with such derogations).

This fragmentation results in higher industry costs since it limits the ability of manufacturers to exploit economies of scale. For example, the need to manufacture rolling stock to meet specific national track and loading gauge, signalling and other standards inevitably reduces the number of trains that can be produced to a given specification and increases the unit cost of production.[19] While the manufacture of pan-European, modular designs capable of accommodating sub-systems that meet national standards is possible, it carries significant risks and requires a thorough understanding of specific standards prevailing in each Member State. Hence, the full potential for greater cost efficiency can only be exploited once a whole-system approach, based on ETCS, has been implemented across the European rail network.

Second, the problem of geographical fragmentation is compounded by fragmentation among rail sub-systems such as rolling stock, infrastructure and signalling manufacture, infrastructure management and railway operations. To some extent, this has been reinforced by EU legislation, notably measures in successive packages of legislation to increase the separation between infrastructure managers and rail undertakings. While such separation is necessary to ensure that access to infrastructure is made available to competing train operators on a non-discriminatory basis, and may stimulate innovation by increasing competitive pressure,[20] it inevitably increases the number of organisations whose efforts must be coordinated if new technologies are to be translated into market innovations.

Third, there is fragmentation along the innovation life cycle, with research projects focusing on low TRLs frequently coming to an end without any plan for follow-up activity leading to market take-up. This aspect of the problem was clearly recognised by stakeholders responding to the consultation undertaken as part of the impact assessment accompanying the proposal to establish the S2R JU, over 85% of whom supported action to enhance development, prototyping and demonstration activities. It is also confirmed by recent research undertaken by Palacin et al (2016),[21] which examined a series of case studies of rail research dating back to 1988 to establish principles for maximising the uptake of innovation. The study concluded that a higher take-up depends on:

- Alignment of research initiatives with an appropriate strategy, ideally taking account of the potential impact and applicability of research results across the industry and supported by effective implementation and communication plans;
- Planning an effective transition between research and implementation, including both appropriate management processes and independent assessment of post project progress using relevant data; and
- Planning for knowledge retention and transfer, in the absence of which the risk that knowledge gained through research effort is lost increases substantially.

[19] Firm evidence of the extent of economies of scale in rolling stock manufacture is limited. However, analysis of rolling stock production in Australia by Deloitte Access Economics indicates that a quadrupling of the size of an order from, say, 40 to 160 vehicles can result in a reduction in vehicle unit cost of around 50%. See Deloitte Access Economics (2013), Opportunities for greater passenger rolling stock procurement efficiency, September 2013, available at: https://www2.deloitte.com/content/dam/Deloitte/au/Documents/Economics/deloitte-au-economics-passenger-rolling-stock-procurement-efficiency-opportunities-270913.pdf.

[20] See Chris Nash and Andrew Smith (2019), op. cit.

[21] Roberto Palacin, David Golightly, Vijay Ramdas and Nastaran Dadashi (2016), Evaluating the impact of rail research: Principles to maximise innovation uptake, Journal of Rail and Rapid Transit, Vol. 230(7) 2016

The challenge of coordinating activity along the innovation life cycle is demonstrated by the analysis undertaken by Foster Rail previously cited.[22] It concluded that for only 33% of projects was there clear evidence that the resulting products, services or processes had been applied by the rail industry in different Member States.

2.2.4 High R&I costs, risks and lead times

In the absence of effective mechanisms for coordinating R&I activity, the fragmentation issues described above undermine the incentives to undertake significant R&I investment. This effect is reinforced by the long product cycles in the rail industry with, for example, locomotives in service for 30 to 40 years as compared with around seven years for a private car and 20 for an aircraft. This means that a given technology can be locked into a rail system for many years, although the adoption of new technologies through more frequent renewal and retrofitting activity is possible. Moreover, it means that the commercial return from such investment, as well as being dependent on the coordinated efforts of various stakeholders with different commercial objectives, may not be realised within the payback period required by those considering it.

In this context, it is important to recognise the impact of rail service contracts, which are limited by EU law to a duration of 15 years, or 22.5 years where the service operator is expected to undertake significant investment. This is likely to be insufficient to realise the full benefits of investment in new operational assets that can enter service in the early years of a contract, much less investment in R&I activity with highly uncertain effects. In addition, while the planning horizons of manufacturers and infrastructure managers are arguably more aligned, unequal distribution of the benefits of innovation can nevertheless undermine incentives to invest. For example, the installation of trackside equipment to allow remote monitoring of train performance may enable more efficient train maintenance from the perspective of a rolling stock supplier but will be costly to install and may not generate a positive business case for an infrastructure manager planning in isolation.

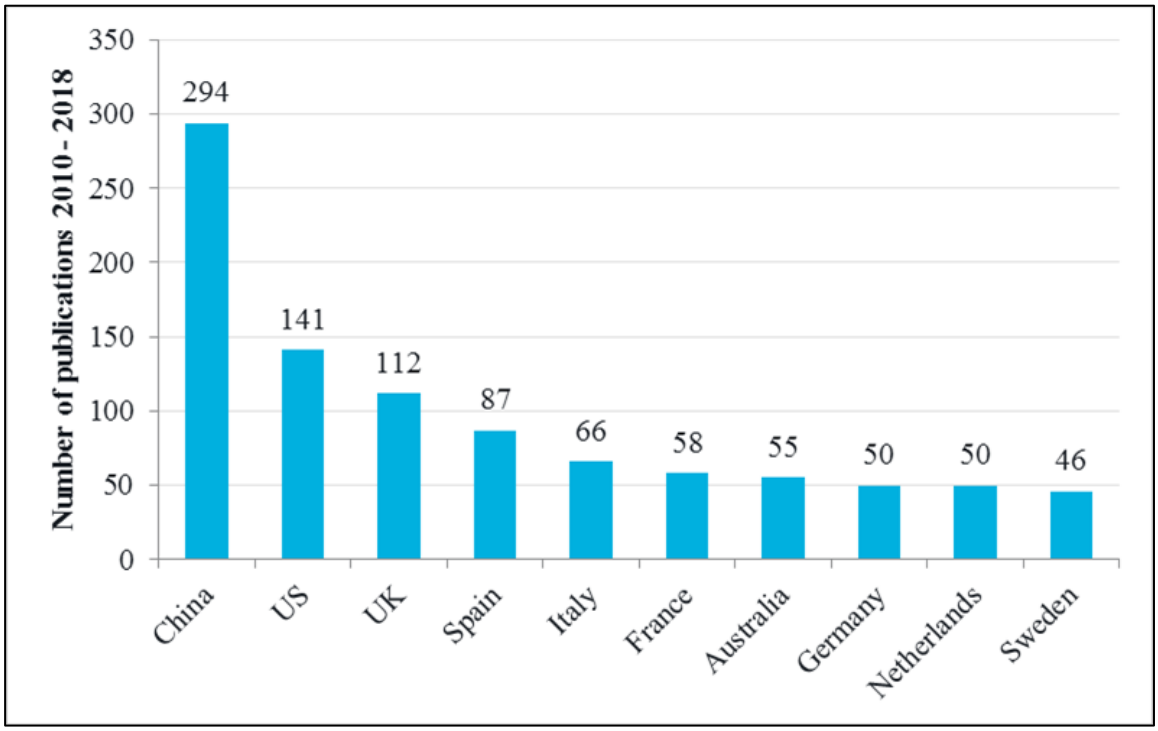
During the **interview** exercise some stakeholders noted that, more generally, the rail transport industry is resistant to change. One manufacturer pointed to the persistence of a view of interlocking resulting from the longevity of, first, mechanical and, subsequently, electric interlocking technology, which have provided the basis for railway signalling over many years. Both infrastructure managers and rail operators have become familiar with the application of such technology, which is considered reliable and safe, and are therefore reluctant to explore the full potential of digital technology, which introduces new and, from their perspective, poorly understood operational and safety risks. While the prevalence of such an industry mindset cannot be demonstrated unequivocally, to the extent that it exists it may act to further undermine the industry's willingness to invest in R&I.

2.2.5 Insufficient development of the knowledge base

Historically, Europe has made a strong contribution to rail-related research, with universities and research-based institutions generating substantial numbers of publications each year. The S2R JU has also begun to contribute to the scientific knowledge base in the field, producing 23 publications from nine projects between 2016 and 2019, although it has not been established long enough to have built a strong profile through publication of results. However, the contribution of other countries, notably China and the US, to published research has also been substantial, and they now account for the largest share of publications relating to research in railways of any country.

[22] See footnote 15.

Figure 3: Leading countries producing research publications in rail and rail systems



Source: Technopolis analysis of Scopus data

The figure below shows the number of publications between 2010 and 2018 for the ten countries leading research in the field. It confirms that China publishes substantially more research results than any other country, including all the main countries in which Europe's RSI is based. Moreover, while collectively the European Member States shown account for more publications than China and the US together, the magnitude of research effort in both these countries is sufficient to suggest that the sustainability of Europe's lead in rail research is at risk, particularly in view of the UK's forthcoming departure from the EU.[23] In addition, the two individual organisations responsible for the highest number of publications over the same period are Chinese universities,[24] together accounting for 48% of all publications produced by the top 10 organisations in the field, while the journal responsible for the most publications is the Tiedao Xuebao Journal of the China Railway Society.

Since rail-related research undertaken today provides the basis for development and innovation in the rail industry in the future, Europe's contribution to the current research effort has implications for the further development and competitiveness of the European RSI.[25] In particular, the number of registered industrial designs and patents generated by the RSI is partly a function of the level of more fundamental research undertaken in the past to which suppliers have had access, either through formal collaboration with research-based organisations or because of a significant in-house research capability. As already noted, the extent to which the industry can maintain intellectual property of this kind is an

[23] The UK's participation in any European R&I initiative in rail, as in other sectors, will depend on its broader relationship with the EU, which has yet to be established at the time of writing.

[24] Beijing Jiaotong University and Southwest Jiaotong University.

[25] While published research results are, by definition, available to industries around the world, suppliers of rail products and services based close to, and potentially working collaboratively with, leading research organisations in the field are likely to benefit most from the research outputs that they produce.

important determinant of its technological lead, and hence its competitiveness, in global markets.

The recent study on the competitiveness of the RSI, undertaken on behalf of the Commission,[26] found that of the 187,642 patents granted worldwide between 2011 and 2017 under the International Patent Classification 'B61 – Railways', 66% were granted by the relevant Chinese authority. It also reported that of the 12,989 patents granted to the 10 companies receiving the most patents over the same period, 53% were granted to the leading Chinese rolling stock manufacturer CRRC and 18% were granted to Japanese suppliers of the rail industry. Moreover, while differences in patent law and practice around the world limit the comparability of patent data, we note that Canada, China, Japan and the US together accounted for 224 of the 3,636 patents granted by the European Patent Organisation over the same five years.

Europe's position in respect of registered industrial designs for railway locomotives and rolling stock is similar, although Japan rather than China dominates the statistics provided by the Global Design Database. Of the 1,533 designs registered between 2011 and 2018, 788 were registered by Japanese suppliers compared to 156 in Germany, 28 in France and 12 in the UK. Among the top 15 companies registering designs, 11 were Japanese and only three European.

Widespread recognition of the importance of these problem drivers was again reflected in the responses to the **OPC**. A majority of business organisations (including SMEs), business associations, academic and research institutions, public authorities and EU citizens considered the various aspects of fragmentation discussed above to be relevant or very relevant. They also confirmed the lack of a coordinated approach to programming and funding and the need to bring together the research community, the RSI, train operators and infrastructure managers. A majority of all these groups similarly considered the market take-up of innovations to be slow, either because of deployment issues or as a result of the regulatory framework.

Several of the stakeholders participating in the **interview programme** similarly stressed the difficulties in overcoming the fragmentation of the European rail system, particularly in view of the perceived slow progress in deploying ERTMS and delivering full interoperability. They also highlighted the long-life cycle of railway assets and the costs and risks of R&I investment as major constraints on the speed of innovation. There was a strong consensus that, in the absence of policy intervention, it would not be possible to achieve the long-term strategy and level of stakeholder participation and coordination needed to translate R&I results into higher quality, more efficient rail services. In addition, some stakeholders expressed the view that, to date, the development of rail freight had been disappointing, and that Horizon Europe represented an important opportunity to substantially improve its competitiveness.

The business organisations providing **feedback on the inception impact report** also confirmed the importance of some of the problem drivers identified above, in particular industry fragmentation. These and other stakeholders, including EU citizens, also emphasised the importance of ensuring that investment in R&I activity made a difference to the rail industry and its customers through more extensive and rapid take-up of innovation.

2.3 How will the problem(s) evolve?

The baseline for the impact assessment of the candidate partnership is defined as traditional calls under Horizon Europe. We have therefore considered how the problem

[26] See footnote 2.

might evolve in light of the evidence relating to R&I in the rail sector before Horizon 2020, which provides an indication of how R&I activity might be undertaken in the absence of any kind of European Partnership. At the same time, we note that the results of R&I activity to date, including that undertaken during and before Horizon 2020, could be expected to benefit the sector during the period of Horizon Europe and beyond.

We have sought to describe the evolution of the problem by reference to various parameters for which we have sufficient evidence to both define a starting value and project changes over time. These are set out in *Table 40* in *Appendix D*. Overall, while we would expect some improvement in the efficiency, capacity and reliability of Europe's rail network based on the achievements of the S2R JU to date, we suggest that this would be limited by the relatively low market take-up of innovation observed before Horizon 2020. In these circumstances, the rail sector would not be in a position to make its anticipated contribution to the realisation of European Green Deal and the various societal development goals identified above.

While we would expect significant development of Europe's contribution to the scientific and technological knowledge base in the railway field under the baseline, it is likely that its universities and research-based institutions would account for a declining proportion of total publications over the next ten years in the face of a strong, ongoing research effort in China and other countries. We would also expect China to continue to dominate in terms of the number of patents granted globally and that the technological advantage conferred by the intellectual property of the European RSI would be eroded to some degree.

Stakeholders responding to the **OPC** were not asked explicitly about how the problem might evolve in the absence of policy intervention. Those participating in the **interview programme** tended to support the view that the lack of progress in addressing issues such as fragmentation and inadequate coordination of R&I activity observed before Horizon 2020 would be likely to remerge in the absence of significant further policy intervention during Horizon Europe. Similarly, stakeholders providing **feedback on the inception impact assessment** tended to suggest that the problems identified in the document would be likely to persist in the absence of policy intervention.

3 Why should the EU act?

3.1 Subsidiarity: Necessity of EU action

The rationale for EU intervention follows directly from the previous discussion of the problem. In particular, it arises from the fact that individual Member States and rail industry stakeholders, whether acting alone or in commercially driven consortia, do not have sufficiently strong incentives to address the problems identified since the benefits of greater investment in R&I at the European level are both uncertain and distributed across a large number of different groups and organisations. R&I sponsored at the national or organisational level, while potentially contributing to the broader development of the European rail system, is therefore unlikely to enable the rail industry to meet European transport and broader environmental objectives. Similarly, it is unlikely to ensure the European RSI's ability to compete in international rail product markets against suppliers based in China and other third countries actively building their indigenous rail sector capability, including through major R&I programmes.

3.2 Subsidiarity: Added value of EU action

The development of a common European strategy and objectives for rail-related R&I would help to ensure a more coordinated, market-focused approach to R&I activity. It would provide a vehicle for aligning such activity with established transport policy objectives, including the completion of SERA, and for ensuring collaboration among actors from across Europe and along the industry value chain to define projects and programmes designed to

address market needs. More specifically, it would support the delivery of a more integrated European rail network, allowing seamless transport of passengers and freight across national borders, while facilitating the development of products and services enabling the European RSI to maintain its global technological lead.

In addition, the coordination of R&I at the European level would help to improve the efficiency of the industry in two important ways. First, it would allow a pooling of resources available for R&I and their distribution according to a common strategy, thereby reducing the potential for competing and conflicting projects focusing on the needs of national networks and tending to reinforce the geographical fragmentation discussed in the previous chapter. Second, it would encourage the RSI to develop products and systems that further enable the development of a fully integrated European rail system, thereby advancing the creation of a single European market for equipment and allowing them to exploit economies of scale in production more effectively (see *Section 2.2.3* and footnote 19). As demonstrated by the success of ERTMS in overseas markets, the development of a common strategy towards rail system development, together with the associated efficiency gains, also has the potential to improve the global competitiveness of the RSI.

Among stakeholders responding to the **OPC** there was widespread recognition of the problem of fragmentation and lack of effective coordination of R&I activity underpinning the case for intervention at the European level. Stakeholders participating in the **interview programme** and providing **feedback on the inception impact assessment** were also generally fully supportive of EU action to address these and other aspects of the problem.

4 Objectives: What is to be achieved?

4.1 General objectives

In order to address the problems identified in *Section 2*, it is important to clarify the objectives of EU action in the field of R&I. We have identified three general objectives corresponding to the main problems discussed in *Section 2.1*.

First, rail-related R&I activity under Horizon Europe should enhance the rail industry's contribution to societal development in Europe. This will mean:

- Increasing its ability to support the delivery of the European Green Deal, partly by further reducing the greenhouse gas and other emissions generated by the rail transport industry itself but more importantly by improving the competitiveness of rail services relative to less environmentally friendly modes such as road and aviation;
- Enabling rail to support the realisation of a people-centred economy in which EU citizens have access to an increasing range of employment, education and leisure opportunities through efficient, attractive and affordable public transport services operating within and between Member States; and
- Supporting rail's contribution to improving the quality of life in European cities, in particular through better integration of rail, other public and newly emerging transport services with a view to increasing connectivity, reducing travel by private car and enhancing air quality and other aspects of the urban environment.

This objective is fully in line with several of the SDGs supported by the Climate, Energy and Mobility Cluster, including SDG 3 (Good Health and Well-being), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action). It is also consistent with the broader objectives of the cluster itself, as described in the report on the overarching context to the impact assessment studies, in particular developing seamless, smart, safe, accessible and inclusive mobility systems.

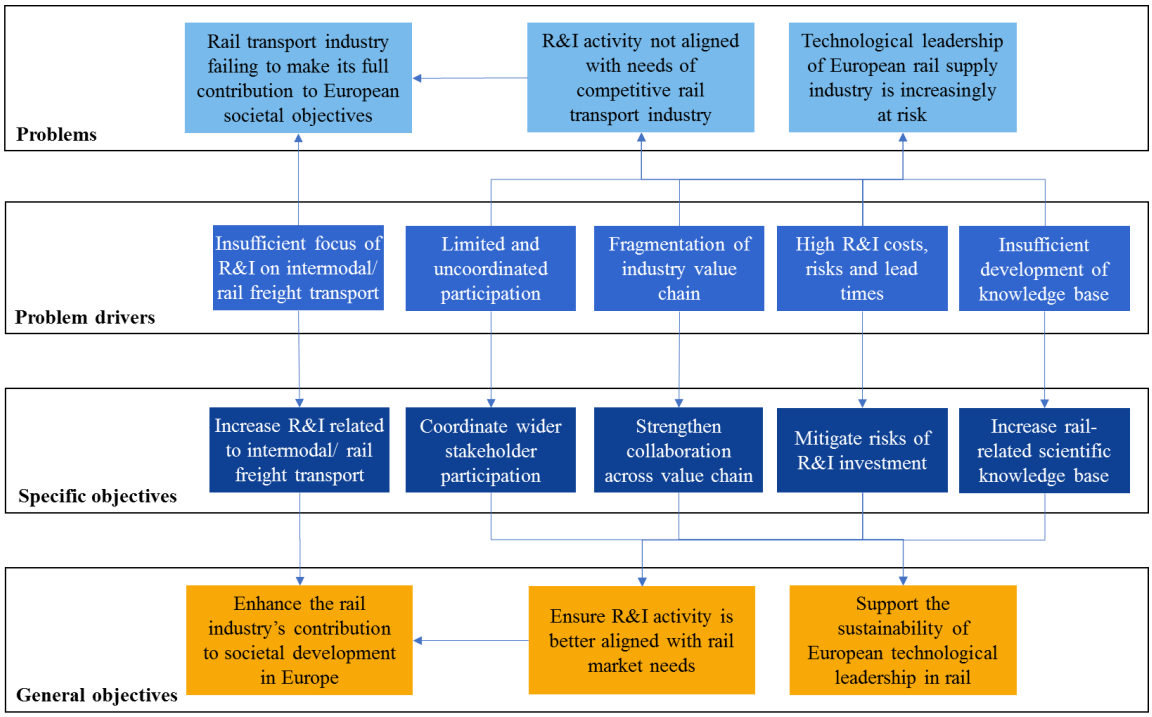
The second general objective is to ensure that rail-related R&I activity is better aligned with rail market needs. This will mean designing R&I programmes that deliver outputs addressing specific issues identified by rail operators, infrastructure managers and other stakeholders through a whole system approach, thereby improving the efficiency of rail services and increasing their attractiveness to passengers and freight customers. This objective is similarly aligned with a number of SDGs, particularly SDG 9 (Industry, Innovation and Infrastructure), and with broader cluster objectives. Note also that meeting the second general objective will facilitate meeting the first, since a rail industry that is better placed to meet the needs of its customers is more likely to increase its share of transport markets.

The third objective is to support the sustainability of European technological leadership in rail. This will mean enhancing the ability of the European RSI to compete in global markets by addressing the issues highlighted in the recent report of the expert group and the study on the competitiveness of the RSI recently published by the Commission[27].

4.2 Specific objectives

In order to achieve the general objectives, we have defined five specific objectives responding to each of the problem drivers discussed in *Section 2.2*. The relationship between the general and specific objectives is shown in Figure 4.

Figure 4: Objectives tree for the initiative for Transforming Europe's Rail System



Increase rail-related scientific knowledge base

Given the growing importance of the contribution of third countries, notably China, to the overall rail industry knowledge base reported in *Section 2.2.5*, it will be important to increase the rail-related scientific knowledge base developed by both European research-focused organisations and the rail industry itself. In the short term, this could be measured by reference to the number of publications in the field produced in Europe and the share of such publications in the global total, providing an early indication of the improvement in the knowledge base that could be expected by the end of Horizon Europe. It will also mean

[27] See footnotes 1 and 2.

increasing the number and strength of the links between relevant European universities and research organisations, on the one hand, and organisations within the rail transport industry and the RSI, on the other.

Strengthen participation and collaboration and reduce risk

As already noted, enhancing the competitiveness of rail transport in Europe will require the development of a more market-focused R&I agenda than has been the case in the past, at least prior to Horizon 2020. In our view, this will require the following:

- The coordination of wider stakeholder participation, including all the actors identified in Table 37, providing them with the mechanisms and incentives to support the specification and delivery of the full range of R&I activity according to their capabilities and objectives – this could be demonstrated by an increase in the number of stakeholders within different categories participating in R&I projects by the end of Horizon Europe.
- Strengthening collaboration across the industry value chain, such that fundamental research is translated into productive development effort and, ultimately, market focused innovation through demonstration and deployment – this could be demonstrated by an increase in the number of projects complying with good practice, as defined by the Foster Rail study of previous projects (see Appendix D) and by progress towards meeting targets for the number and value of demonstration projects.
- Mitigating the risks of R&I investment for organisations within the RSI and the rail industry seeking to develop and deploy new products and services – this could be demonstrated by a measurable increase in the level and intensity of such investment under Horizon Europe as compared with previous Framework programmes.

As indicated further below, these objectives, particularly those relating to wider participation and stronger collaboration are strongly supported by a range of stakeholders responding to the OPC and participating in the interview programme for this study.

Increase R&I related to intermodal and rail freight transport

Given the importance of rail freight and intermodal transport services in meeting European societal objectives, we also propose a specific objective of increasing R&I related to these two markets. The extent to which this had been achieved by the end of Horizon Europe could be measured by reference to one or more simple metrics, such as the number of projects explicitly focused on improving rail freight and intermodal services and/or the proportion of total R&I resources used in support of such projects.

Note also that meeting the specific economic and technological objectives described in the previous section can be expected to enable the delivery of a more competitive rail transport sector, which will itself contribute to the achievement of environmental objectives by encouraging modal shift.

We noted in *Section 1* that stakeholders from several different groups responding to the **OPC**, including business organisations of different sizes, business associations, academic and research institutions, public authorities and EU citizens, largely endorsed the view that a European Partnership should be responsive to societal needs and make a significant contribution to global competitiveness. A majority in each of these groups also considered the need to align R&I with market requirements to be relevant or very relevant. There was similar recognition of the importance of better integration of freight services, notably among public authorities and EU citizens.

Stakeholders participating in the **interview programme** proposed a range of general and specific objectives. There was strong support for making rail the backbone of the European

transport system by improving its competitiveness, and several stakeholders identified a need to achieve greater integration of rail and other modes (including through greater focus of R&I activity on intermodal and rail freight transport). Most stakeholders also supported the objective of supporting the competitiveness of the RSI in global markets. However, a limited number of interviewees, primarily from within the rail freight and logistics community, indicated that aiding the RSI in this way was not an appropriate use of EU resources. Rather, they considered that any policy intervention under Horizon Europe should be directed towards ensuring that investment in R&I addressed specific issues faced by rail operators in meeting their customers' needs, for example capacity constraints limiting the volume of freight services provided.

Stakeholders providing **feedback on the inception impact assessment** were generally fully supportive of the objectives identified in the document, in particular improving the competitiveness of the rail transport industry and maintaining Europe's technological lead in rail systems. Several, including both large and small business organisations, also supported the aim of improving rail's contribution to meeting European societal objectives, in particular in relation to climate action, improving connectivity and stimulating economic growth and job creation.

4.3 Intervention logic and targeted impacts of the initiative

4.3.1 Likely scientific impacts

The initiative is likely to lead to two key scientific impacts, as illustrated in *Figure 5*. These are relatively long term in nature, but we would expect to see clear evidence of them by the end of Horizon Europe.

Figure 5: Impact pathway leading to scientific impacts

Future rail-related R&I, whether supported through open calls or some form of formal partnership arrangement, will continue to contribute to scientific knowledge through the publication of results. Given the participation of a wide range of stakeholders with complementary skills and capabilities, coupled with appropriate peer review mechanisms, this should enable the development of a strong science base comparable to that in countries such as the USA and China with a growing track record of research in the field.

Such research activity will provide opportunities for research staff located in both the rail industry and academic and research institutions. Moreover, building momentum in rail-related research over the medium to long term will enable more individuals to pursue a career in the field, possibly involving periods working in an academic as well as an industry environment. It could also contribute to building relationships between universities and research-based institutions and the industry, including formal organisations similar to UKRRIN[28] and informal networks. This would result in an increase in the overall number of high-quality jobs across the European economy.

[28] UK Rail Research and Innovation Network, a network of centres of excellence encompassing several leading universities in the field of rail research and Network Rail's Rail Innovation and Development Centres. The

Further, R&I activity at TRL 1-3 is particularly important in generating a pipeline of new ideas that could have practical applications in the future. By its nature, the direction of fundamental research activity cannot be predicted with confidence, but the activity covered by the S2R JU's IPX illustrates some areas that might be investigated further under Horizon Europe. These include:

- the use of blockchain technology in the management of remote condition monitoring data;
- investigation of medium voltage DC electrification systems for railways to reduce the need for investment in conventional AC-based infrastructure; and
- means of strengthening collaboration between rail stakeholders to encourage new areas of investigation.

Pursuing fundamental research of this kind will help to ensure that a pipeline of future innovation opportunities can be maintained, and that the technological solutions offered by the RSI are continually refreshed.

Among **OPC** respondents a majority of business organisations (both large organisations and SMEs), business associations, academic and research institutions, EU citizens and public authorities considered the creation of new scientific knowledge and capabilities by the candidate institutionalised partnership for the rail sector to be relevant or highly relevant. Most of these groups also expected the partnership to create high quality jobs in the sector, although public authorities were less persuaded of the importance of this impact.

A majority of the **stakeholders interviewed** agreed that it was important to undertake projects across the TRLs to build the scientific knowledge base and secure the future pipeline of potential innovation. They identified a wide range of research needs, many focusing on the exploitation of digital technology to improve both the quality and efficiency of rail services. Many interviewees, particularly train operators, infrastructure managers and representatives of the RSI, emphasised the importance of programming sufficient development and demonstration projects to ensure market take-up of R&I results. Some also highlighted the need to ensure transparency and better dissemination of results to maximise the impacts of the initiative.

Stakeholders providing **feedback on the inception impact assessment** generally supported the view that an initiative under Horizon Europe would have important scientific impacts. One response from an academic and research institution noted that the quality of European research in rail depended on the promotion of the initiative and several highlighted its potential contribution to Europe's ongoing technological leadership in the sector. However, two small business organisations indicated a need to refocus the research on cutting edge technologies, in particular hyperloop systems capable of substantially increasing the speed of 'rail' services.

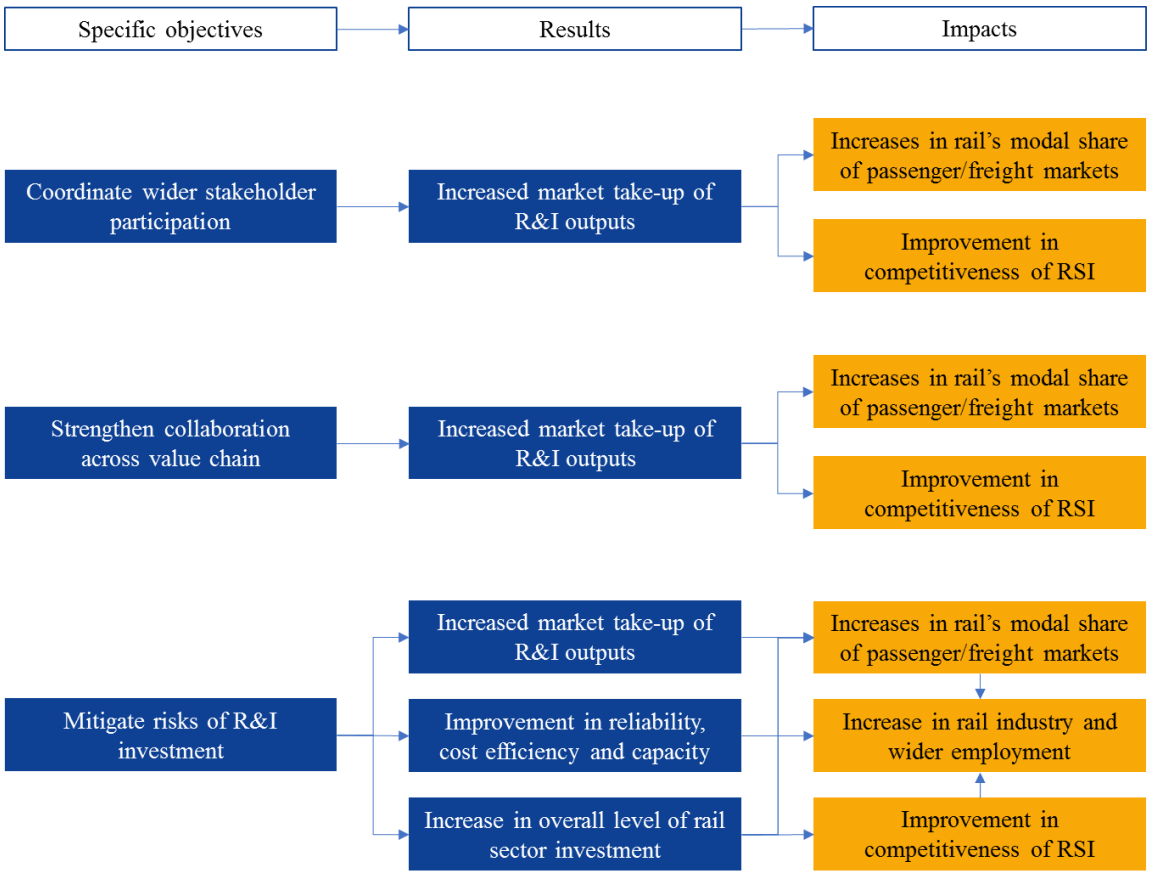
4.3.2 Likely economic/technological impacts

The likely key economic/technological impacts of the initiative are mapped in *Figure 6*. These pathways are varied and relatively complex, as shown in the figure, although all lead to an increase in rail's share of freight and passenger transport markets while supporting the development of the RSI.

organisation has a coordinating hub that links academic experts, suppliers, SMEs and others to rail industry experts with a view to encouraging market-focused research.

The coordination of wider stakeholder participation, for example among rail freight and urban transport operators, will ensure that R&I activity addresses a wider range of issues across the rail transport industry, with individual projects and programmes informed by the different perspectives of infrastructure managers, train operators and users of rail services as well as suppliers. It will also encourage greater involvement of SMEs, who have the flexibility to develop innovations and bring them to market relatively rapidly, and of technology-based organisations outside the rail industry, who can challenge silo-based programming of activity and increase industry awareness of emerging technologies with potential applications in rail.

Figure 6: Impact pathways leading to economic/technological impacts



Overall, we would expect this objective to lead to a more market-focused approach to R&I, with a higher proportion of projects leading directly to innovations that are taken up by the rail transport industry in Europe and/or incorporated into products and services that are offered in global markets by the RSI. Hence, as shown in the figure below, it will lead to an improvement in the competitive position and market share of rail services in European transport markets, including both passenger and freight markets, and an improvement in the global competitiveness of the RSI.

Strengthening collaboration across the industry value chain will contribute positively to the market take-up of innovations via various routes. Building stronger links between different organisations in different parts of the value chain will make it easier to align their activities with a common set of objectives, reducing the risk of duplicated and uncoordinated effort. It will also provide a platform for planning the progression of R&I activity through the TRLs, with the development of strategic plans defining the transition from fundamental research, through the development stage, to demonstration and deployment. Finally, it will enable more effective leveraging of Commission resources, since stakeholders will be more confident of the potential returns from supporting the initiative if their contribution is part of a collaborative effort reflecting differences in capability and expertise. Again, we would

expect these outputs from the objective to be mutually reinforcing, with a higher proportion of R&I projects leading to innovations that benefit both the rail transport industry and the RSI.

However, while the previous two objectives are likely to have a positive effect on the proportion of projects taken up by the market, on their own they are unlikely to lead to a transformational change in the level and intensity of investment in rail-related R&I. This will require proactive mitigation of the risks of R&I, as reported in *Section 2.2.4*, through both the provision of Commission funding and the implementation of a framework under Horizon Europe in which stakeholders considering the business case for investment can be more confident of the expected returns. Stimulation of a higher level of investment in R&I, potentially more comparable with the levels achieved in other sectors, will result not only in higher market take-up of the outputs of R&I projects but also material improvements in the reliability, cost efficiency and capacity of the European rail network.

We would also expect the pursuit of this objective to result in a substantial, and potentially transformational, increase in overall rail sector investment. This is because a material improvement in the whole-life efficiency of the rail transport industry would have the potential to unlock significant additional investment resources, bringing forward the enhancement of the network for the benefit of passengers and freight customers. In practice, given that the industry continues to rely heavily on public sector funding, the extent of such investment will depend on policy priorities at the local and national level, with policy makers trading-off the benefits of reduced rail fares and freight rates (passing on the benefits of greater efficiency to users of rail services) against increased investment and/or reduced subsidy levels. In our analysis of the impacts of different options reported in *Section 6*, we have assumed that 50% of any cost savings arising from greater efficiency are reinvested in the network, with the remaining 50% passed on to passengers and freight customers.[29]

Given the transformational nature of this additional investment, the associated impact on the competitiveness of rail transport services and on their modal share is likely to be significant. It will also give further impetus to the RSI's ability to compete in global markets, for example by demonstrating the capability of European rolling stock, train control systems and infrastructure solutions to potential purchasers in third countries. Taken together, these impacts can be expected to generate significant additional employment in the rail sector.

We also note that pursuit of these objectives in combination will support the completion of SERA, for example by providing technical solutions to the remaining open points under different TSIs and enabling interoperability between different national rail systems. More generally, it will contribute to the delivery of various targets for the development of the European transport system identified in the 2011 White Paper,[30] including those relating to enhancements in network capacity. For example, advances in train management and control will have a key role to play in increasing the capacity of existing infrastructure without building more lines.

As the impacts described above depend on substantial enhancement of rail networks across Europe through, inter alia, the replacement of legacy and long-lived rolling stock, infrastructure and systems, they are only likely to be fully realised over the next 20 to 30 years. However, as in the case of scientific impacts, we consider that a material and

[29] The assumption of a 50:50 allocation of cost savings between investment and reductions in the cost of using rail transport is arbitrary but represents a common basis on which to compare options.

[30] See *Appendix D*.

measurable improvement in the modal share of rail services by the end of Horizon Europe is possible.

Stakeholders responding to the **OPC** confirmed the importance of a range of economic impacts, with a substantial majority of larger business organisations, business associations and academic research institutions considering impacts such as the increased competitiveness of the European rail industry, economic efficiency, market take-up of scientific and technological developments and a transition to digitalisation and enhanced multimodal interfaces to be very relevant. The responses among SMEs, public authorities and EU citizens were more varied, although a majority of all of these groups similarly recognised the importance of these impacts, considering them to be relevant or very relevant. All of the public authorities responding to the OPC considered economic efficiency to be a very relevant impact and a majority also highlighted the importance of enhancing vehicle capacity to accommodate higher passenger and freight volumes.

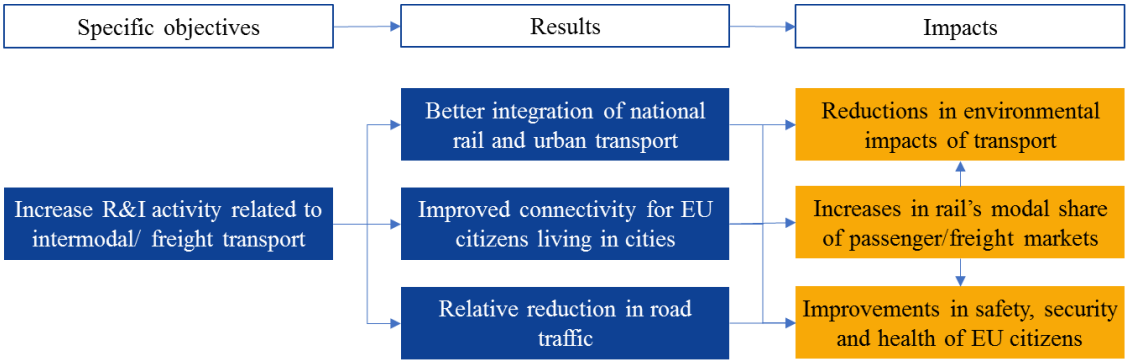
Several stakeholders included in the **interview programme** highlighted the importance of encouraging participation among a wider group of actors as a precondition of delivering economic and technological benefits. They confirmed that greater involvement of SMEs and research organisations could be expected to lead to more disruptive thinking and a reduction in the time needed to bring new products and services to the market. Some stakeholders also made specific proposals for expanding participation to include verification and certification bodies, national authorities (responsible for policy on harmonisation of standards), a wider group of train operators and infrastructure managers and port and terminal operators (who can bring a customer perspective to the specification of projects intended to improve the attractiveness of rail freight services). Many interviewees emphasised the importance of coordinating the contributions of these different organisations in both the development of a long-term strategy for rail-related R&I and the preparation of a supporting work programme enabling collaboration within and between individual projects.

Stakeholders providing **feedback on the inception impact assessment** generally confirmed that an initiative under Horizon Europe could be expected to deliver substantial economic and technological benefits, including greater market take-up of innovation and an associated step change in the competitiveness of the rail transport industry. As previously noted, a number of EU citizens noted the potential for R&I to transform the passenger experience and several stakeholders suggested that the benefits for rail freight could be substantial.

4.3.3 Likely societal impacts

The economic and technological impacts discussed above will also support the achievement of societal impacts, as shown in Figure 7. The initiative will be particularly important in achieving sustainable development goals, not least SDG 13 (Climate Action), since a significant increase in the modal share of rail services in European transport markets will reduce the demand for less environmentally friendly forms of transport. In addition, we suggest that an increase in R&I activity focused on rail freight and intermodal transport, leading to innovations that enhance the attractiveness and accessibility of these services for existing and potential users, will have broader societal impacts. The timescales over which these impacts are likely to be observed are similar to those for others already discussed, since they also partly depend on the deployment of innovation on established networks and hence the replacement of legacy assets with long lives.

Figure 7: Impact pathway leading to societal impacts



Likely environmental impacts

R&I activity focused on various elements of intermodal and urban transport, including rail-based services such as tram and metro and the interface between national rail services and urban networks of different kinds, has the potential to improve the quality of the urban environment in several ways. In particular, the provision of a more integrated transport network within cities across Europe would reduce the need for car travel, reducing congestion and improving air quality while contributing to target reductions in greenhouse gas emissions.

Similarly, greater innovation in the rail freight industry, suitably focused on the needs of the industry's customers, could substantially increase service quality, such that logistics companies and shippers considered rail as a competitor to road transport across a much wider range of markets and distances than at present. This effect would be reinforced if innovation also improved the efficiency of freight services, allowing operators to reduce freight rates. Taken together, these effects could significantly reduce the level of road freight traffic, particularly on inter-urban and inter-regional routes, thereby contributing to a reduction in greenhouse gas and other emissions.

Likely social impacts

A greater emphasis on the integration of national, regional and local rail systems with other modes, including through the development of collective transport systems that combine conventional rail with new services such as flexible mobility, could greatly improve connectivity across and between Member States. This will benefit EU citizens, including persons with restricted mobility (PRMs), by enabling greater freedom of movement, notably for those living in peripheral regions and remote locations whose journey opportunities would otherwise be limited. Hence, as previously noted the initiative will contribute to the achievement of key policy objectives such as SDG 8 (Decent Work and Economic Growth) and SDG 9 (Industry, Innovation and Infrastructure).

The development of more integrated and accessible urban transport systems will also further improve the quality of life for many EU citizens by enhancing connectivity within and between cities, providing access to a wider range of opportunities for employment, education and leisure. It will similarly promote the broader well-being of urban populations, for example by improving air quality and road safety. In addition, to the extent that R&I activity is directed towards improving the safety and security of collective transport services, users of such services will benefit from a safer travelling environment and reductions in the level of service disruption. Together, these impacts will contribute to the achievement of SDG 11 (Sustainable Cities and Communities).

4.3.4 Likely impact on simplification and/or administrative burden

We do not anticipate any material impact in terms of simplification of the administrative burden of rail-related R&I activity supported under Horizon Europe.

4.3.5 Likely impacts on fundamental rights

Since the exercise of fundamental rights is frequently dependent on individual mobility, the rights of EU citizens will be significantly strengthened through investment in intermodal transport systems. For example, they will have greater freedom to pursue career, educational and leisure opportunities of their choice and to travel in a safe, secure and healthy environment. In addition, PRMs will be able to access such opportunities more easily, ensuring that they are not discriminated against because of a reduced ability to travel. Access to international rail and other transport hubs for all citizens will be facilitated, encouraging mobility between Member States.

Again, **OPC** respondents endorsed the importance of many of these impacts, with a substantial majority of business organisations and associations (including SMEs), academic and research institutions and EU citizens considering the contribution to cleaner mobility at lower cost and a reduction in noise, energy consumption and emissions to be very relevant. Similar levels of support were expressed in respect of safer and more reliable infrastructure and rolling stock, improving the quality of passenger and freight services and a reduction in the use of fossil fuels. Public authorities and EU citizens were particularly concerned with impacts on safety and reliability as well as on service quality more generally.

Many **interviewees** were similarly of the view that the initiative could have substantial societal impacts if sufficiently focused on the integration of European rail services into the wider transport system. Several noted the potential for R&I to improve the attractiveness of both freight and urban transport services, reducing environmental emissions and road congestion and improving connectivity for EU citizens. Some also identified the development of low carbon technologies, noise reduction and improved safety and security as key research priorities.

Several stakeholders providing **feedback on the inception impact assessment**, including both business organisations and EU citizens, agreed that the environmental benefits from achieving modal shift to rail through innovation would be considerable. A number also endorsed the view that appropriate application of new technology could help to improve the integration of rail services into the wider transport system, delivering further benefits for the European population in terms of greater connectivity and ease of travel.

4.4 Functionalities of the initiative

This section outlines the functionalities that need to be considered when assessing the policy options in *Section 6*, reflecting the selection criteria for European Partnerships defined in the Commission proposal for the Horizon Europe Regulation.[31] In the following paragraphs, we discuss the implications of the criteria relating to the type and composition of the actors involved, the range of activities to be undertaken and the directionality required if the initiative is to deliver the objectives discussed above. We also consider the complementarities and synergies with other, related initiatives under Horizon Europe and beyond.

[31] European Commission (2018), Proposal for a Regulation of the European Parliament and of the Council establishing Horizon Europe – the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018PC0435&from=EN.

4.4.1 Internal factors

Type and composition of the actors involved

This functionality relates to the criterion *"Involvement of partners and stakeholders from across the entire value chain, from different sectors, backgrounds and disciplines, including international ones when relevant and not interfering with European competitiveness".* It concerns the need to involve the full range of stakeholders that can usefully contribute to delivering the future R&I agenda.

In Section 2.2.2 we discussed the difficulties of securing the participation of key stakeholders in collaborative R&I and in Section 4.2 we identified a specific objective to 'coordinate wider stakeholder participation'. Inclusion of the full range of industry and other stakeholders is essential if the initiative is to leverage all relevant expertise and capability, from both inside and outside the industry, and result in R&I outputs that address a broader set of industry needs than in the past.

Table 3: Type and composition of actors

	RSI – original equipment manufacturers	RSI – sub-suppliers including SMEs	Infrastructure managers	Passenger train operators	Freight train operators and logistics services	Urban transport operators	Universities and research institutions	Technology-based organisations	Port and terminal operators	Certification bodies
Long term perspective	✓	✓	✓	✓			✓	✓	✓	✓
R&I proposals	✓	✓	✓	✓		✓	✓	✓		
Flexibility and disruptive thinking		✓					✓	✓		
Asset management expertise	✓		✓	✓	✓	✓			✓	✓
Expertise in train operation				✓	✓	✓				✓
Understanding of passenger needs	✓			✓		✓				
Understanding of freight customer needs					✓				✓	
Understanding of current R&I[32]	✓	✓	✓	✓			✓	✓		
Financial resources	✓		✓							
Dedicated in-kind support	✓		✓	✓						✓
Ad hoc in-kind support	✓	✓	✓	✓	✓	✓			✓	

Source: Steer analysis based on research into previous framework programmes and stakeholder engagement

[32] We have identified the actors most likely to have knowledge of the R&I programme currently managed by the S2R JU and other national programmes.

The table above lists the stakeholders that need to be involved and indicates the capabilities that they can bring.[33] There may also be a need to change the profile of stakeholder participation over the life of the initiative, for example by providing for successive 'waves' of participation (with members selected according to their potential contribution to an evolving R&I agenda), and/or more flexibility in the rules governing participation to ensure that specific gaps in expertise can be filled effectively and efficiently.

Type and range of activities

This functionality relates to the criterion "Approaches to ensure flexibility of implementation and to adjust to changing policy, societal and/or market needs, or scientific advances". It concerns the types of activity that the initiative is intended to encourage, such that it is able to respond effectively to the challenges and problems described in Section 2.

Our investigation of current developments in R&I suggests the following will be particularly important in meeting the objectives described in Section 4.2:

- Further exploration of the benefits of critical technologies, for example 5G, digital maintenance, automation, cybersecurity and new track materials, the realisation of which can be expected to both increase the efficiency and competitiveness of European rail transport services and strengthen the technological lead of the European RSI;
- The development of technologies supporting a step change in the competitiveness of the rail freight sector, such as global track and trace, remote monitoring of the cargo environment, automated loading and unloading and remote monitoring of wagon condition,[34] and
- The application of technology to achieve better integration of national rail and urban transport networks and the exploitation of collective transport, for example harnessing big data to provide tailored travel information for passengers connecting between different modes, including during periods of service disruption.

The delivery of this activity will require coordination across the TRLs, with a base level of fundamental research leading to development work focused on industry and market needs, and to subsequent demonstration activity designed to provide firm evidence of the potential benefits of innovations for users and providers of rail services. While the profile of participation will need to change as work progresses along the innovation life cycle, it will be important to ensure some continuity, such that stakeholders familiar with the outputs of, say, a given development project have a role in the subsequent demonstration programme.

It will also be important to establish links with other, related fields of research and associated policy interventions, as discussed in *Section 4.4.2,* for example through the specification of joint R&I programmes sponsored under two or more initiatives with a common focus on a particular field of research or technological application. At the same time, it will be necessary to provide for greater flexibility in defining the scope of R&I programmes, perhaps with periodic opportunities to identify modifications to existing

[33] Note that the table indicates the type of actor most likely to make a particular contribution based on their characteristics. For example, while it is possible that original equipment manufacturers will contribute to disruptive thinking, we consider that, in general, SMEs are more likely to exhibit this approach.

[34] See, for example, Rail Freight Forward, 30 by 2030: Rail Freight Strategy to Boost Modal Shift, available at: https://www.railfreightforward.eu/about-rail-freight-forward, for a discussion of how digital technology, together with other factors, could increase the modal share of rail freight to 30% by 2030.

activity and/or new programmes in response to emerging technological developments, new market opportunities and changing priorities.

Directionality and additionality required

This functionality relates to the criteria "Common strategic vision of the purpose of the European Partnership" and "Creation of qualitative and significant quantitative leverage effects". The former highlights the importance of ensuring that all participating stakeholders have a common understanding of the purpose of the policy intervention and the direction of the R&I activity it is intended to encourage. The leverage effects relate to the creation of spill-overs of knowledge gained in the broader community as well as the crowding-in of private investment in R&I, both among participating stakeholders and in the broader community, and/or the pooling of resources from EU Member States.

Under Horizon Europe, an industry-led approach to shaping R&I strategy at the European level will be needed to ensure that R&I activity continues to support improvements in the attractiveness of rail services in Europe and strengthens the ability of the RSI to compete in global markets. At the same time, we have noted the different incentives and constraints faced by the various industry stakeholder groups, and the consequential difficulties of ensuring that 'bottom up' collaboration, driven primarily by commercial incentives, delivers outcomes that are aligned with policy objectives. This argues for a more 'top down' approach to the development of a common strategic vision, recognising both the primacy of key policy goals and the potential contribution that different stakeholders can make to achieving them.

Any initiative focused on rail-related R&I under Horizon Europe must therefore enable or support the following:

- The development of a long-term vision of an integrated European railway system: the further development of Europe's railways will need to be based on a whole-system approach to investment, cutting across the various interfaces discussed in Section 2.2.3, that recognises the long-lived nature of railway assets. This, in turn, will require an R&I strategy focused on system transformation and complementary to the various European and national policy and regulatory initiatives intended to enhance network integration, for the benefit of both passenger and freight services.
- Alignment of the R&I strategy with EU policy objectives: the strategy must support the completion of SERA, in particular through the delivery of technical solutions that can increase the level of interoperability of the European rail network. The implementation of such solutions must be coordinated with ERA and relevant national regulatory bodies. As discussed in *Section 3.2*, this will both enable more seamless transport of passenger and freight traffic across national boundaries and allow the RSI to better exploit economies of scale within a larger European market for common rail equipment and systems.
- Dialogue at the national and international level: the initiative must enable effective dialogue between those engaged in R&I activity and those responsible for rail policy and regulation at the international and national level (including international standards bodies). In practice, the R&I community will need a powerful voice, enabling it to challenge the assumptions underpinning prospective regulations. This will ensure that R&I proceeds in a way that supports the development and implementation of standards and that, conversely, the specification of standards is informed by R&I outputs. In addition, the dialogue will need to extend to corresponding actors working elsewhere in the transport field, in particular those focused on the integration of transport modes in both the passenger and freight sectors.
- Maximum leverage of available resources: the initiative will also need to ensure that limited resources available for R&I are used as efficiently as possible, and that EU funds

are supplemented by financial and/or in-kind resources provided by the RSI, the rail transport industry and technology-based organisations from outside the rail sector. It must be based on a stable framework governing both the commitment and distribution of resources, providing those participating in the initiative with confidence that the returns from R&I activity will be commensurate with their investment. In the absence of such a framework, stakeholders may redirect resources to competing national R&I programmes that may be poorly aligned with European policy goals and/or risk duplicating effort.

- Transparent decision-making and visibility of outputs: the initiative must be supported by decision-making processes that involve all relevant stakeholders and ensure clear accountability for results. It will also need to be subject to clear rules governing intellectual property, striking a balance between, on the one hand, protecting organisations making substantial investment in R&I and, on the other, ensuring that the outputs of individual projects are sufficiently visible to enable further development and high rates of market take-up.
- Relationships with third countries: there will be an ongoing need to enable participation of, and engagement with, rail sector and other organisations based in third countries, subject to reciprocity arrangements. The initiative must therefore provide for a framework governing such relationships that ensures that EU funding of R&I activity results in scientific, economic/technological and societal benefits within the EU[35]. At the same time, it must enable exploration of opportunities for the RSI to reduce its dependence on inputs sourced from outside the EU.

4.4.2 External factors

The proposed Regulation for Horizon Europe also identifies the need to consider "Coordination and complementarity with Union, local, regional, national and, where relevant, international initiatives or other partnerships and missions" when assessing the case for a partnership. It concerns the potential for links with other relevant R&I initiatives proposed or planned for the forthcoming Framework Programme, at the EU level under the MFF 2021-27, and beyond.

We have already provided an overview of the links between the candidate partnership and others in the Climate, Energy and Mobility cluster (see *Section 1.3*). There is also a case for building links with initiatives established under other clusters, particularly given the need to meet the specific objectives of increasing both the overall rail-related scientific knowledge base and R&I activity related to intermodal and freight transport. At this stage it would be premature to identify a definitive list of links, but the following provide an illustration of the possible synergies between R&I in rail and other areas:

- Application of digital technology – there are various ways of applying digital technology to improve rail services, from the perspective of both service providers and users. Applications range from improving the functionality of ERTMS and advances in e-ticketing to global track and trace services for freight customers and remote monitoring of axle wear for train operators. Links with partnerships in the Digital, Industry & Space cluster are therefore likely to be of critical importance under Horizon Europe.
- Exploring complementarity with road transport – while the focus of the Towards Zero-emissions Road Transport initiative within the Climate, Energy and Mobility cluster will be on reducing the direct environmental impact of road transport, reducing overall emissions from land-based transport will also depend on securing modal shift to rail. This argues for joint R&I programmes to identify integrated transport solutions that

[35] See footnote 34 on the implications of the UK's departure from the EU.

exploit the benefits of different modes at different stages of the journey and minimise environmental impacts.

- Exploiting developments in battery and fuel cell technology and other forms of power – such technology has applications in different parts of the transport sector, and it is important that the potential benefits for rail of further developments in different sources of power are fully explored. For example, the use of battery technology in new rolling stock can help to bring forward the transition from diesel to electric power, which would otherwise depend on costly electrification of infrastructure, and hence to accelerate the delivery of both greater fuel efficiency and environmental benefits. Any policy intervention in support of rail-related R&I could also enable the industry to help shape the direction of research into new power sources.[36]

We also note the importance of links with the following broader initiatives, which can be expected to support the achievement of the general objectives described in *Section 4.1*:

- The Digital Europe Programme (DEP) will focus on reinforcing Europe's capacities in high performance computing, artificial intelligence, cybersecurity and advanced digital skills and ensuring their wide application across the economy and society.[37] Given the importance of digital technology in the rail industry, coordination between any future initiative concerning rail-related R&I and the DEP should help to strengthen the competitiveness of rail passenger and freight services and the ability of the RSI to compete internationally.
- The Connecting European Facility (CEF) will develop and modernise the trans-European networks in the fields of transport, energy and digital and facilitate cross-border cooperation in the field of renewable energy, taking account of long-term decarbonisation commitments and with emphasis on synergies among sectors.[38] CEF is expected to target synergies in the areas of connected and autonomous mobility, clean mobility based on alternative fuels, energy storage and smart grids.[39] Again, several of these technologies have important applications in the rail sector, as discussed further in *Appendix C*.

The European Regional Development Fund (ERDF) and Cohesion Fund (CF), which aim to increase economic and social cohesion and reduce imbalances and disparities between the regions of the European Union, may also provide funding to support the further development of rail networks in different Member States. The investment priorities for ERDF include delivery of the digital agenda and broader support for R&I. These funds are particularly relevant in view of the need to strengthen the participation of rail sector stakeholders from across Europe in the specification and delivery of R&I programmes that are relevant to their needs.

[36] The S2R JU and the Fuel Cells and Hydrogen 2 JU have already sponsored joint research on the use of fuel cells and hydrogen in a railway environment. Such coordination between initiatives can be expected to continue under Horizon Europe.

[37] European Commission (2018), Proposal for a Regulation of the European Parliament and of the Council establishing the Digital Europe programme for the period 2021-2027, COM(2018) 434 final

[38] European Commission (2018), Proposal for a Regulation of the European Parliament and of the Council establishing the Connecting Europe Facility and repealing Regulations (EU) No 1316/2013 and (EU) No 283/2014, COM(2018) 438 final

[39] European Parliamentary Research Service (2018), Connecting Europe Facility 2021-2027 - Financing key EU infrastructure networks, BRI(2018)628247

5 What are the available policy options?

In this chapter, we provide an overview of the key characteristics of the policy options for this initiative. The Horizon Europe regulations put forward three forms of European Partnership that constitute the policy options. Standard Horizon Europe calls is a fourth option that also provides a baseline against which the partnership options can be compared.

To ensure a thorough assessment of the different options and their effectiveness, it is crucial to take into consideration both the objectives and the functional requirements outlined in *Section 4*. The descriptions of the options in the sections below therefore focus on the implications of the options' characteristics related to these functionalities, as listed in *Appendix E*. A full description of the options is provided in the report on the overarching context to the impact assessment studies.

5.1 Baseline option – Traditional calls under the Framework Programme

As indicated in Table 4, under the baseline option coordination of R&I would be heavily reliant on the mechanisms for managing open calls.

Table 4: Key characteristics of the baseline – Option 0

	Implications of option
Enabling appropriate profile of participation (actors involved)	• The Commission would need to consult extensively with a wide range of stakeholders to translate the strategic R&I agenda for rail into an annual work programme. • A well-defined process would be needed to ensure that the programme committees were properly informed about R&I priorities, including key demonstration programmes. • The specification of calls over the period of the Framework Programme could reflect the need for an evolving profile of participation, with different consortia forming at different stages to take different types of activity forward.
Supporting implementation of R&I agenda (activities)	• Implementation would rely on standard infrastructure underpinning the open calls procedure, drawing on resources of executive agencies and Commission IT systems. • Calls for proposals would be published in the work programmes of Horizon Europe. • Transparency and open publication of results would ensure their availability to interested parties.
Ensuring alignment with R&I agenda (directionality)	• Work programmes would need to reflect the requirement for R&I activity across TRLs, with input from representatives of all relevant stakeholders. • Specification of calls for activity at higher TRLs, particularly demonstration programmes, would need substantial input from industry. • Calls would need to be informed by S2R JU IPs to ensure continuity where appropriate • R&I activity would focus on the short to medium term needs of the industry, although it would also include fundamental research. • Commission input into specification and oversight of calls would help to ensure alignment with overarching policy objectives but full integration with other programmes would require additional coordination.

	Implications of option
Securing effective leveraging of resources (additionality)	• Progress of R&I effort would depend largely on EU funding, with no expectation of significant leveraging of industry support. • Given more limited funding than in the past, critical R&I priorities would need to be identified at the outset.

5.2 Option 1: Co-programmed European Partnership

A co-programmed partnership would provide for focused input from partners into the determination of the R&I agenda and clear aspirations for leveraged funding of activity while continuing to rely on the Commission and/or executive agencies for administration. At the same time, while it would allow for flexibility in the profile of stakeholder participation, progress in the delivery of the R&I programme would depend on the willingness of stakeholders to support individual projects subject to open calls.

Table 5: Key characteristics of Option 1

	Implications of option
Enabling appropriate profile of participation *(actors involved)*	• The partnership would enable participation by all key stakeholders potentially contributing to the specification and delivery of the strategic R&I agenda. • It would need to consult with a wide range of stakeholders to ensure that the R&I agenda, and ultimately the work programme, was aligned with industry and market needs. • At the same time, it would offer the flexibility to change the profile of participation over time, with new partners joining to support new areas of activity in response to emerging results and changing priorities.
Supporting implementation of R&I agenda *(activities)*	• Implementation would rely on standard administrative infrastructure underpinning the open calls procedure, drawing on resources of relevant executive agencies and Commission IT systems. • Calls for proposals would be published in the work programmes of Horizon Europe. • Transparency and open publication of results would ensure their availability to interested parties.
Ensuring alignment with R&I agenda *(directionality)*	• Work programmes would need to reflect the requirement for R&I activity across TRLs, with input from the various partners to achieve an appropriate balance of activity directed towards different markets (e.g. urban and freight transport). • The partnership would be responsible for ensuring that priorities for calls were specified in line with R&I priorities, including demonstration programmes. • Specification of calls would need to be informed by S2R JU IPs to ensure continuity where appropriate. • R&I activity would nevertheless be likely to focus on the medium-term needs of the industry. • Transport Programme Committee would ensure alignment with overarching policy objectives and coordination with related programmes.

	Implications of option
Securing effective leveraging of resources ***(additionality)***	• Aspirations for partner contributions would be clearly defined at the outset. • Expected in-kind contributions from the private sector would be identified in the work programme.

5.3 Option 2: Co-funded European Partnership

Since private sector stakeholders from the rail industry could not participate directly in a co-funded partnership, the R&I programme would need to be developed by national funding bodies and/or research instiutions before being agreed with the Commission. In addition, it would not be possible to leverage Commission funding with private sector resources under this option.

Table 6: Key characteristics of Option 2

	Implications of option
Enabling appropriate profile of participation ***(actors involved)***	• Since private sector entities cannot participate in this form of partnership, national funding bodies or governmental research institutions would need to support the development of an R&I programme to be agreed with the Commission. Such bodies and institutions might need to be created, since hitherto the R&I effort in many Member States has been led by private sector organisations. • National bodies would need to consult widely with their respective rail sectors to develop a market-focused R&I strategy.
Supporting implementation of R&I agenda ***(activities)***	• Funds would be distributed either according to the rules applying to relevant national funding arrangements or under a centrally managed open calls procedure. • Private sector entities hitherto sponsoring a significant level of R&I activity in the rail sector would not be eligible to receive funding.
Ensuring alignment with R&I agenda ***(directionality)***	• In principle, would enable a broad range of activities across the TRLs but the alignment of these with industry needs would need to be by proxy, with national research institutions consulting on the R&I agenda with industry stakeholders. • The Commission would ensure alignment with overarching policy objectives and coordination with related programmes. The R&I strategy would nevertheless focus on common national priorities.
Securing effective leveraging of resources ***(additionality)***	• It would not be possible for private sector organisations to contribute directly to the resourcing of the partnership and leverage of Commission funding would therefore be limited.

5.4 Option 3: Institutionalised European Partnership

5.4.1 Institutionalised Partnerships under Art 185 TFEU

As in the case of Option 2, an institutionalised partnership under Article 187 of the TFEU would not be open to private sector participation. Hence, while the R&I strategy and work programme could in principle address long term issues affecting the rail industry at the European level, it would need to be developed by Member States rather than being industry-led. In addition, the partnership would not be able to leverage significant private sector funding.

Table 7: Key characteristics of Option 3

	Implications of option
Enabling appropriate profile of participation *(actors involved)*	• Since private sector entities cannot participate in this form of partnership, Member State representatives would need to support the development of an R&I programme to be agreed with the Commission. • Member States would need to consult widely with their respective rail sectors to develop a market-focused R&I strategy.
Supporting implementation of R&I agenda ***(activities)***	• Funds would be distributed according to the rules of the partnership and managed by a dedicated implementation structure. • Private sector entities hitherto sponsoring a significant level of R&I activity in the rail sector would not be eligible to receive funding.
Ensuring alignment with R&I agenda ***(directionality)***	• In principle, would enable a broad range of activities across the TRLs but the alignment of these with industry needs would need to be by proxy, with Member States consulting on the R&I agenda with industry stakeholders. • The Commission would ensure alignment with overarching policy objectives and coordination with related programmes. The R&I strategy would focus on major challenges requiring collective action at the European level.
Securing effective leveraging of resources ***(additionality)***	• Leveraging of Commission resources would be primarily through pooling of Member State funding. • While, in principle, the partnership could attract strategic private sector investment, it would not provide a vehicle for coordinating R&I funding from private sector stakeholders within the rail industry.

5.4.2 Institutionalised Partnerships under Art. 187 TFEU

An institutionalised partnership established under Article 187 of TFEU would provide a structured framework for bringing together the capabilities of all stakeholders potentially contributing to rail-related R&I under Horizon Europe. This would include dedicated administrative resources to support the development of the strategic R&I agenda for the whole of the Framework Programme and legally binding funding arrangements.

Table 8: Key characteristics of Option 3

	Implications of option
Enabling appropriate profile of participation *(actors involved)*	• The partnership would enable participation by all key stakeholders potentially contributing to the specification and delivery of the strategic R&I agenda through a clearly defined membership structure. • It would provide a forum for consulting stakeholders on R&I priorities and the work programme, ensuring that they were aligned with industry and market needs. • Participation would be less flexible than under other options, but it might nevertheless be possible to change the profile of participation over time, with new partners joining to support new areas of activity in response emerging results and changing priorities.
Supporting implementation of R&I agenda ***(activities)***	• A dedicated administrative structure would be established to coordinate the specification of R&I activity, manage implementation and report on the results (with administrative expenditure subject to rules relating to its level and distribution).
Ensuring alignment with R&I agenda ***(directionality)***	• The partnership would be responsible for specifying a work programme fully in line with the R&I priorities identified by the industry, combining activity across the TRLs (including key demonstration programmes) and in different areas (e.g. urban and freight transport). • The work programme would reflect the medium to long term needs of the industry, drawing on the perspectives of different stakeholders. • The work programme would build on, but not be constrained by, the current programme to ensure continuity where appropriate. • Commission participation in the partnership governance arrangements and approval of the work programme would help to ensure alignment with overarching policy objectives and enable integration with other programmes.
Securing effective leveraging of resources ***(additionality)***	• Legally binding funding requirements would be clearly defined at the outset, with private sector partners expected to provide between 50% and 75% of partnership resources through in-kind and/or financial commitments

5.5 Options discarded at an early stage

The co-funded partnership (Option 2) and an institutionalised partnership created under Article 185 of the TFEU (a version of Option 3) are not considered relevant for the impact assessment of the Transforming Europe's Rail System partnership. This is because of the need to secure the engagement of private sector and other commercial organisations in the sponsorship, programming and delivery of R&I, not least because of the key role of such organisations in both the delivery of rail services in Europe and the supply of rail-related products and services in global markets. As the only forms of partnership in which the private sector can participate are the co-programmed partnership and the Joint Undertaking established under Article 187, the analysis in the following section is restricted to a comparison of these options with the baseline option of open calls under Horizon Europe.

6 Comparative assessment of the policy options

6.1 Assessment of effectiveness

Based on the intervention logic, the initiative aims to deliver scientific, economic/technological and societal (including environmental) impacts through a set of pathways, as described in *Section 4.3*. If they are to be achieved as effectively as possible, the set of critical factors described in *Section 4.4* must be in place. This section assesses the extent to which the retained policy options, the characteristics of which are described in *Section 5*, can enable the scientific, economic/technological and societal impacts to be achieved. At the end of each section we summarise the outcomes of the assessment by assigning a non-numerical score to each option for each impact.

The assessments in this section provide the basis for the comprehensive comparative assessment of all retained options against all dimensions in *Section 6.4*. *Table 9* lists the desired impacts in the three impact areas.

Table 9: Likely impacts of the initiative

Impact area	Likely impacts
Scientific impact	An increase in the number of high-quality jobs in Europe
	A strengthened pipeline of potential innovation available to the RSI and rail transport industry
Economic / technological impact	An increase in rail's modal share of passenger and freight markets
	An improvement in the competitiveness of the RSI
	An increase in rail industry and wider employment
Societal impact	Reductions in the environmental impacts of transport
	Improvements in the safety, security and health of EU citizens

6.1.1 Scientific impacts

Option 0: Horizon Europe calls (baseline)

We would expect R&I activity under the baseline option to make a significant contribution to the scientific knowledge base, with the volume of publications from European universities and research-based organisations increasing at a rate similar to that observed during previous Framework Programmes. The open calls procedure would enable a pipeline of projects at TRL 1-3, contributing to the global knowledge base while providing a platform for future innovation by stimulating further activity at TRL 4 and above. The outputs obtained would continue to underpin the registration of patents and industrial designs by the European RSI, with the overall level of new intellectual property created each year broadly comparable to that reported in *Section 2.2.5*. The pipeline of activity generated by open calls would also provide opportunities for SMEs and, possibly, technology-based organisations outside the rail sector, to participate in projects across the TRLs.

However, the scientific impacts under this option would be limited by a number of factors:

- The resources available to support R&I under Horizon Europe would be constrained, not least because of the disengagement of public sector infrastructure managers and rail operators that could not secure approval to participate on the same scale as under Horizon 2020 (as discussed further below in the context of technological and economic impacts).
- It would be difficult to coordinate the wider participation among stakeholders needed to develop and implement a strategic agenda focusing R&I effort on long-term industry

and market needs, since the composition of consortia responding to open calls could not be easily directed and managed according to a common strategy.

- There would be a substantial risk of duplication of effort, with different projects focusing on related issues and potentially resulting in contradictory conclusions, tending to undermine the progression of further work through the higher TRLs to deployment.
- It would not be possible to fully address the problem of fragmentation of the R&I life cycle through the application of good practice in recording, disseminating and building on the outputs of individual projects (see Section 2.2.3 and Appendix D), since there would be some dislocation between open calls issued at different times and no guarantee that the appropriate stakeholders would be involved throughout a given research programme.
- The effective monitoring, assessment and dissemination of any results obtained would be challenging in the absence of a dedicated administrative structure and might also be complicated by a lack of well-defined rules providing for a balance between transparency and appropriate protection of intellectual property. This would act as a further disincentive to both participation and investment in R&I.

Against this background, we would expect Europe's contribution to the knowledge base to develop piecemeal under the baseline option, with China continuing to strengthen its position in the publication of fundamental research and to dominate the creation of new intellectual property. The number of jobs in the field in Europe would be unlikely to change significantly, and the number and strength of the links between the scientific community and the rail transport industry might even decline.

Option 1: Co-Programmed

We would expect a greater degree of participation from some stakeholders within the European rail sector as well as from SMEs and technology-based organisations under a co-programmed partnership than under the baseline option. Stakeholders would be required to make some commitment to progressing a programme of R&I activity under a memorandum of understanding, which would provide a platform for dialogue and the development of a more strategic approach to the direction of effort, based on common objectives. This would enable the requirements for directionality and additionality described in *Section 4.4.1* to be addressed to some degree. Hence, the scientific impacts under this option would probably be greater than those described above, with European universities and research-based organisations making a stronger contribution to the volume of publications and the RSI registering marginally more patents and industrial designs.

However, the impacts would again be constrained by the lack of participation of key stakeholders from the rail transport industry, in particular infrastructure managers and national train operators. For these stakeholders, a co-programmed partnership would not provide sufficient certainty of return from committed resources, notwithstanding the more formal framework of collaboration provided by a memorandum of understanding. Moreover, while the R&I programme would be developed by the partners, as under the baseline projects would be launched as individual calls and undertaken by ad hoc consortia with little incentive to coordinate their work, either with other projects at the same TRL or with stakeholders interested in the application of the results.

This option would therefore be subject to many of the same limitations as the baseline, namely constraints on available resources as compared with Horizon 2020, insufficient rail industry participation to ensure a market-focused approach to innovation, lack of coordination across TRLs, less effective monitoring and dissemination of results and inadequate management of intellectual property issues. Hence, the option would do little to address the threats to the RSI's technological lead discussed in *Section 2.2.5*.

Option 3: Institutionalised Art 187

An institutionalised partnership established under Article 187 would be subject to a well-defined legal framework, with partners contributing resources in accordance with legally binding requirements relating to the proportion of EU and partner funds, set out in a Council Regulation. It would be governed and managed through dedicated structures supporting, inter alia, the development of a long-term strategy for rail-related R&I and the specification of annual work programmes delivered through projects undertaken either by specific partners or through open calls.[40] This would ensure that the functionalities described in *Section 4.4* were fully addressed. In particular, it would provide for:

- An appropriate profile of participation, including all the stakeholders identified in Table 3 and taking account of different expertise and perspectives from across Europe, along the rail industry value chain and in different sectors, (with the potential to modify the profile over the period of Horizon Europe according to the needs of the strategy and an evolving work programme);
- The development of a long-term strategy for rail-related R&I, with basic research and development activity aligned with European policy objectives for the rail sector;
- A higher level of overall funding, not least because of a commitment of financial and in-kind resources from rail industry organisations who are better able to engage under a legally binding framework governing the allocation of resources; and
- Effective management of a pipeline of activity covering basic research, development and demonstration, with an appropriate allocation of resources to projects at different TRLs.

In our view, these factors would considerably strengthen the scientific impact pathway described in *Section 4.3.1*, since they would increase the resources available for research at TRLs 1 to 3 while supporting the coordination of activity required to translate the outputs from such research into intellectual property for exploitation both within Europe and in global markets. They could also be expected to strengthen the networks linking universities and research-based organisations, on the one hand, and actors within the rail industry, on the other. One of the main benefits of establishing the S2R JU was bringing representatives of different types of organisation with an interest in rail-related R&I together within a single forum, since it enabled individuals to exchange expertise and proposals for research in a way that was not possible before Horizon 2020. Such interaction can also generate opportunities for individuals to move between a research and industry environment and increase the number of high-quality jobs in the field.

In addition, the development of a network of organisations through the establishment of a stable platform for engagement, supported by a dedicated administrative structure, can reinforce the impact of research in several ways. In particular, it can stimulate ideas for research and more opportunities for the industry to help shape the research agenda in line with market needs, with different stakeholders competing to influence the direction of research and identify concrete opportunities for further innovation. This, in turn, can encourage interest from organisations that have not previously participated, including SMEs and entities from outside the rail sector, resulting in a more dynamic process of exchange and collaboration.

[40] We understand that the Commission is considering the implementation of a policy whereby all activity programme by a JU would be subject to open calls. In our view, this would have important implications for the ability of JUs to effectively leverage partner contributions and could substantially undermine the beneficial impacts of a JU described here.

The **OPC** responses tended to confirm the importance of several of the factors that in our view would contribute to more effective delivery of scientific impacts under an institutionalised partnership.[41] For example, a substantial majority of business organisations and associations, academic and research institutions, public authorities and EU citizens considered the inclusion of a broad range of partners, with flexibility to change the profile of participation over time, was either relevant or very relevant. The responses also indicated a widely held view among the same groups that the initiative should enable the development of a long-term strategy for rail-related R&I that draws on input from the rail industry, academia and, to a lesser extent, Member States and associated countries. There was strong support for pooling and leveraging resources, particularly those available from industry and academia.

Most the **stakeholders interviewed** for this study, including manufacturers, train operators and infrastructure managers, supported the view that the scientific and other impacts of rail-related R&I under Horizon Europe could be best achieved through an institutionalised partnership. Again, they tended to emphasise the importance of the factors identified above, in particular the development of a long-term strategy, greater participation across a wider range of stakeholders and more effective leveraging of EU funding, in ensuring that development of the scientific knowledge base enabled useful market innovation. At the same time, some suggested that more emphasis should be placed on 'blue sky research' during Horizon Europe than had been the case under Horizon 2020.

Almost all of the stakeholders providing **feedback on the inception impact assessment** were similarly supportive of an institutionalised partnership able to develop a long-term strategy for both fundamental research and market-focused innovation. However, as previously noted, a limited number of respondents proposed a reorientation of the research agenda to encompass cutting edge technologies such as hyperloop. In addition, as discussed further below in the context of economic and technological impacts, an EU citizen expressed the need for caution in assessing the likely impact of a continuation of the S2R JU.

Summary

Table 10 shows the scores we have assigned for each of the policy options, based on the assessment above and taking account of the views expressed by the different stakeholders.

Table 10: Overview of the options' potential for achieving scientific impacts

	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 3: Institutionalised Article 187
Increase in number of high-quality jobs	+	++	+++

[41] Note that the responses reported above and in the remaining sections of this section exclude those from organisations that appear to have engaged in a campaign to support the implementation of an institutionalised partnership to succeed the S2R JU. These organisations are either members of the JU or have participated in R&I projects that it has managed during Horizon 2020.

	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 3: Institutionalised Article 187
Strengthened pipeline of potential innovation	+	+	+++

Notes: Score +++: Option presenting a *high* potential; Score ++: Option presenting a *good* potential; Score +: Option presenting a *low* potential

6.1.2 Economic/technological impacts

We have estimated most of the quantifiable economic/technological impacts of the options using a model originally developed for a Study on the Cost and Contribution of the Rail Sector, undertaken on behalf of DG MOVE in 2015[42] (hereafter the cost and contribution model). Note that while we consider the modelling results are sufficiently robust to support a comparison of options, they do not represent forecasts.

An outline of the modelling methodology is provided in *Appendix B.* Here we note that the calculation of impacts is based largely on two key assumptions, which vary by option:

- The assumed market take-up of the outputs of R&I activity under Horizon Europe, informed by the analysis of previous projects undertaken by Foster Rail on behalf of ERRAC; and
- The assumed potential efficiency improvements in rail passenger and freight services arising from the same R&I activity, measured in terms of a percentage reduction in the whole-system costs of service provision per passenger-km and tonne-km and derived from the KPIs and targets of the S2R JU.[43]

By combining these assumptions, we have generated an estimate of the overall impact of R&I on the efficiency of the rail transport industry, taking account of the potential indicated by R&I outputs and market take-up of the associated innovations.[44] Impacts are calculated relative to a default scenario based on traffic projections from the Commission's PRIME-TREMOVE modelling framework and assuming no material improvements in rail industry efficiency.

Option 0: Horizon Europe calls (baseline)

The technological and economic impacts under the baseline option would be similarly limited by the difficulties of coordinating wider stakeholder participation and strengthening collaboration in accordance with a long-term strategy. A number of key stakeholders,

[42] Steer (2015), Study on the Cost and Contribution of the Rail Sector, September 2015, available at: https://ec.europa.eu/transport/sites/transport/files/modes/rail/studies/doc/2015-09-study-on-the-cost-and-contribution-of-the-rail-sector.pdf.

[43] Note that we are not assuming that the KPIs currently monitored by the S2R JU are necessarily appropriate for a future initiative under Horizon Europe. However, they provide a useful way of defining the effects of R&I that can be used in the assessment of impacts.

[44] As indicated in *Table 40*, the figure of 33% represents the percentage of projects taken up by the market but, in the absence of other data, has been used as a proxy for the percentage impact of a given R&I output on the market as whole.

including infrastructure managers and other organisations reliant on public sector funding, would be unlikely to participate in European R&I activity to the same extent, and might completely disengage, if support from the Commission took the form of open calls alone. This could be expected to undermine the market value of the outputs, since the specification of projects would be more heavily influenced by the RSI, albeit subject to Commission oversight, with infrastructure managers and train operators less involved in the direction of R&I strategy. Even a partial disengagement of the rail transport industry would also make it more difficult to programme demonstration activity (which involves the application of new technology in a real railway environment), limiting the market take-up of potentially valuable innovation.

In addition, as previously noted, lack of participation on the part of some stakeholders would reduce the level of investment in R&I during Horizon Europe as compared with that under Horizon 2020. In particular, the withdrawal of infrastructure managers and large public sector train operators with a long-term perspective and access to in-kind and financial resources would substantially limit the scope of activity. Progress towards transformative change, for example through delivery of the kind of efficiency, punctuality and capacity targets previously defined for the S2R JU, would therefore be considerably slower.

Table 11: Technological and economic results and impacts of Option 0

Range of values in 2031		Lower	Upper
Results	Market take-up of R&I outputs (%)	25	33
	Improvement in reliability and punctuality of high-speed passenger services (%)	7.3	9.6
	Improvement in reliability and punctuality of regional passenger services (%)	12.8	16.8
	Improvement in reliability and punctuality of rail freight services (%)	19.5	25.7
	Reduction in railway costs compared to default scenario (€ bn)	6.6	8.7
	Increase in railway investment compared to default scenario (€ bn)	3.3	4.3
Impacts	Increase in passenger traffic compared to default scenario (bn passenger-km)	13.0	17.0
	Rail modal share of passenger traffic by 2031 (%)	9.2	9.2
	Increase in freight traffic compared to default scenario (bn tonne-km)	13.0	17.0
	Rail modal share of freight traffic by 2031 (%)	17.9	18.0
	Increase in total employment compared to default scenario by 2031	116	154

Source: Steer analysis based on rail industry cost and contribution model

Table 11 shows the estimated range of technological and economic impacts of Option 0, derived from the cost and contribution model described in *Appendix B* and informed by the discussion above. Note that increases and decreases are calculated as the difference between modelled values for the option in 2031 and the corresponding values under the default scenario projecting traffic volumes and costs before taking account of the effects of the options.

As indicated, we consider that the market take-up of outputs from R&I projects under the baseline option would be unlikely to exceed 33% and could be as low as 25%, based on the evidence of take-up rates before Horizon 2020. We also consider that progress towards achieving the KPI targets established for the S2R JU would be constrained due to the lack of commitment to R&I among key stakeholders and the difficulties of coordinating effective demonstration projects. This would limit improvements in the reliability and punctuality as well as the efficiency of rail operations achieved under this option. For example, based on the potential improvement of 29% in the reliability of high-speed passenger rail services indicated by release 2.0 of the S2R JU's KPIs, we estimate that the improvement under the baseline would be at most 9.6% (29% × 33%) and could be as low as 7.3% (29% × 25%). Similarly, the percentage reduction in the costs of passenger rail services is estimated to be between 4.1% and 5.4% under the baseline (delivering the reduction in costs of €6.6 - 8.7 billion in 2031 shown in the table), well below the potential 16.5% suggested by release 2.0.

The relatively low market take-up of innovation and lack of progress in delivering R&I outputs that can improve the competitiveness of the rail transport industry similarly lead to modest impacts in terms of modal shift and employment. The increase in rail passenger traffic for 2031 shown in the table, driven by the increase in investment,[45] is equivalent to around 3.8% of all such traffic in all Member States recorded in 2016, while the increase in rail freight traffic is around 4.1% of the total in the same year. Further, we estimate rail's modal share of both passenger and freight transport in 2031 to be little changed from current levels.

It is not possible to assess the impact of the baseline option on the competitiveness of the European RSI from the modelling analysis, which focuses on the effects of different levels of efficiency on the rail transport industry. As now, the success of the RSI in exporting equipment and systems will continue to depend on the extent to which it understands and addresses the needs of a wide range of customers in different regions and countries, which will be only partly influenced by R&I activity supported under Horizon Europe. However, given our observations about the development of Europe's contribution to the scientific knowledge base and intellectual property under an open calls approach, in particular the risk of insufficient industry participation leading to R&I projects lacking market focus, it seems likely that the RSI's technological lead relative to its counterparts in countries such as China, Japan and the US would be further eroded. Moreover, this effect could be compounded by the absence of a single voice representing the stakeholders involved in rail-related R&I, potentially limiting the dialogue with international standards agencies and other regulatory bodies able to influence the specification of rail products and services supplied around the world.

[45] The model assumes a simple relationship between railway investment and increases in passenger and freight traffic, based on the expectation that investment will both improve the attractiveness of rail services and increase available capacity.

Option 1: Co-Programmed

We would not expect the market take-up of innovation to increase substantially under a co-programmed partnership, although some increase might be expected given a more structured approach to industry participation compared with one based entirely on open calls. We have assumed a take-up rate of between 45% and 60%, representing a significant but not necessarily transformative improvement on the rate achieved before Horizon 2020 and reflecting the degree of uncertainty surrounding the impact of this option.[46] Similarly, we have assumed further progress towards the potential efficiency targets set for the S2R JU, going beyond the release 2.0 KPI values.

The results and impacts estimated for this option are shown in *Table 12*. As indicated, the increase in railway investment and the associated increases in passenger and freight traffic are limited and the resulting change in rail's modal share is therefore small, although marginally above that achieved in the baseline.

Table 12: Technological and economic results and impacts of Option 1

Range of values in 2031		Lower	Upper
Results	Market take-up of R&I outputs (%)	45%	60%
	Improvement in reliability and punctuality of high-speed passenger services (%)	15.8	21.0
	Improvement in reliability and punctuality of regional passenger services (%)	23.0	30.6
	Improvement in reliability and punctuality of rail freight services (%)	35.1	46.8
	Reduction in railway costs compared to default scenario (€ bn)	17.9	23.9
	Increase in railway investment compared to default scenario (€ bn)	9.0	11.9
Impacts	Increase in passenger traffic compared to default scenario (bn passenger-km)	36	49
	Rail modal share of passenger traffic by 2031 (%)	9.5	9.6
	Increase in freight traffic compared to default scenario (bn tonne-km)	36	49
	Rail modal share of freight traffic by 2031 (%)	18.4	18.7

[46] There is no direct experience of a co-programmed partnership in the rail sector and hence no firm evidence on which to base the market take-up assumption. While stakeholders have expressed major concerns about the likely level of commitment and distribution of resources under this option, it is possible that these could be mitigated to some degree through changes to its legal and financial framework currently under consideration. This is reflected in the choice of 60% for upper end of the range of market take-up tested through the modelling.

Range of values in 2031		Lower	Upper
	Increase in total employment compared to default scenario by 2031	317	423

Source: Steer analysis based on rail industry cost and contribution model

Moreover, as under the baseline, we would expect the European RSI's technological lead to be eroded under this option, since it would not enable sufficient incremental investment in R&I, over and above that which the industry would anyway undertake, to deliver a step change in the level of both fundamental research and market-focused development. In addition, the lack of a single voice representing the industry in discussions with international standards organisations and other regulatory bodies could further constrain the RSI's ability to supply new and existing global markets. Hence, while the marginal increase in intellectual property could strengthen the industry's position in some countries, for example those where there is potential to deploy ERTMS, this would probably be insufficient to address the challenge from countries such as China and Japan.

Option 3: Institutionalised Art 187

Since an institutionalised partnership would ensure the functionalities described in *Section 4.4* more effectively than either of the other options, it could be expected to deliver substantially higher technological and economic impacts. In particular, greater participation among a wider group of stakeholders, including key actors within the rail transport industry as well as SMEs and technology-based organisations, coupled with better coordination of R&I effort along the value chain, would enable a substantially higher level of demonstration activity. A number of stakeholders highlighted the importance of such activity and noted the difficulty of delivering demonstration projects in the absence of a strong planning function capable of developing a strategic research agenda and supporting work programmes.

Some stakeholders also suggested that market take-up of outputs had increased during Horizon 2020, with one indicating a current take-up rate of 75% (although we have been unable to verify this by reference to any objective data). The S2R JU itself stated that, in view of the higher cost of establishing a JU and the additional resources available to it, such a partnership should target a market take-up rate of between 50% and 100%. In estimating the impacts of this option, we have assumed a take-up rate of between 50% and 75% and that the efficiency targets set for the current JU are achieved by 2031. The results and impacts are shown in *Table 13*.

Table 13: Technological and economic results and impacts of Option 3

Range of values in 2031		Lower	Upper
Results	Market take-up of R&I outputs (%)	50	75
	Improvement in reliability and punctuality of high-speed passenger services (%)	14.5	21.8
	Improvement in reliability and punctuality of regional passenger services (%)	25.5	38.3
	Improvement in reliability and punctuality of rail freight services (%)	39	58.5

Range of values in 2031		Lower	Upper
	Reduction in railway costs compared to default scenario (€ bn)	39.8	59.7
	Increase in railway investment compared to default scenario (€ bn)	19.9	29.8
Impacts	Increase in passenger traffic compared to default scenario (bn passenger-km)	87	140
	Rail modal share of passenger traffic by 2031 (%)	10.0	10.6
	Increase in freight traffic compared to default scenario (bn tonne-km)	86	139
	Rail modal share of freight traffic by 2031 (%)	19.6	20.8
	Increase in total employment compared to default scenario by 2031	705	1,058

Source: Steer analysis based on rail industry cost and contribution model

As shown, these improvements lead to a significant increase in the competitiveness of the rail transport industry, with rail's share of passenger traffic rising to 10% or more and its share of rail freight traffic reaching around 20% by 2031. The increase in rail industry and other employment under this option is also substantially higher than under those previously discussed. The increment relative to the default scenario in 2031 is three times that under a co-programmed partnership and six times the value under the baseline.

The RSI would similarly benefit from the greater resources, interaction with a wider range of stakeholders and improved coordination of R&I effort unlocked through the establishment of a JU. We have already noted that we would expect these factors to enable a step change in both the level of fundamental research and the volume of new patents and industrial designs generated through further development work. We further suggest that:

- Stronger links between the RSI and the rail transport industry, established through regular engagement to help design and implement R&I projects, would also provide suppliers of railway equipment and systems with greater insights into industry and market needs, helping them to improve the added value of their products and services in European as well as other regional markets.
- At the same time, by providing a single voice for the RSI and broader R&I community, the JU could facilitate dialogue with standards agencies and other bodies often acting as gateways to new markets, challenging new and existing regulations where appropriate and providing European suppliers with insights into different regulatory frameworks. It would also be able to engage with relevant policy makers in Member States and third countries.

Hence, while the competitiveness of the RSI will continue to depend on policy intervention in third countries, notably levels of funding for R&I and protection for its indigenous RSI provided by the Chinese government, we would expect European suppliers to be in a stronger position to respond under an institutionalised partnership than under the options previously discussed.

The **OPC** responses provide further support for the view that a well-defined legal structure of the kind underpinning an institutional partnership could be expected to increase the economic and technological impacts of the initiative. A substantial majority of business organisations of different sizes, business associations, academic institutions, public authorities and EU citizens considered that such a structure was either relevant or very relevant for achieving more effective and faster implementation of the initiative, increased financial leverage, better links to both regulators and practitioners on the ground, more long-term commitment from partners and harmonised standards.

A majority of the **interviewees** representing train operators, infrastructure managers and the RSI considered that an institutionalised partnership was essential if EU sponsorship of rail-related R&I was to have a transformative economic and technological impact on the sector. In the view of a number of key stakeholders involved in the S2R JU, the legal framework established under this approach, together with the associated commitments in respect of the provision and allocation of funding, was essential if major public sector stakeholders were to obtain internal and external approval for their participation. It followed that, in the absence of such a framework, these stakeholders would substantially reduce their support for, or even disengage from, an initiative to promote rail-related R&I under Horizon Europe. This did not mean that changes to the scope, management and administration of the activity, in particular greater flexibility to change both participation and the profile of projects over the life of the programme, were not needed. However, most stakeholders considered that such flexibility could be accommodated within the framework of an institutionalised partnership.

A limited number of interviewees, including some representatives of the freight and logistics community and a European train operator, considered that an institutionalised partnership was not a sufficiently open and transparent vehicle to ensure that R&I was focused on market needs. In their view, the S2R JU had prioritised the development of technologies promoted by the RSI and there had been insufficient opportunities for a broader range of stakeholders to influence the direction of R&I activity and become involved in individual projects. Hence, these stakeholders tended to support either the baseline option or a co-programmed partnership (which provide similar opportunities for different stakeholders to respond to calls on an open and transparent basis).

Most of the organisations providing **feedback on the inception impact assessment** also strongly supported the implementation of an institutionalised partnership. They considered such a partnership to be significantly more effective in delivering economic and technological impacts, noting that it would be better placed to develop a long-term strategy for R&I investment, coordinate the contributions of different stakeholders and ensure efficient use and better leverage of EU funding. At the same time, several noted the importance of providing for greater flexibility in the programming of individual projects and modifying the profile of participation. Echoing the concerns of a limited number of interviewees mentioned above, one EU citizen suggested that the major and rapid innovation needed to transform the rail industry would not necessarily be achieved under a framework in which major suppliers with an interest in promoting particular technologies and systems had undue influence over the R&I agenda.

Summary

Table 14 shows the scores that we have assigned to each of the policy options in respect of economic/technological impacts.

Table 14: Overview of the options' potential for achieving economic/technological impacts

	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 3: Institutionalised Article 187
Increase in rail's modal share of passenger/ freight markets	+	++	+++
Improvements in the competitiveness of RSI	+	+	+++
Increase in rail industry and wider employment	+	+	+++

Notes: Score +++: Option presenting a *high* potential; Score ++: Option presenting a *good* potential; Score +: Option presenting a *low* potential

6.1.3 Societal impacts

Option 0: Horizon Europe calls (baseline)

The societal impacts, which partly derive from the economic and technological impacts, would be correspondingly limited under the baseline option. We estimate the net reduction in CO_2 emissions in 2031 relative to the default scenario to be between 0.4 and 0.5 million tonnes (after taking account of the impact of increased traffic levels and the transfer of traffic to rail), with a value of €18 - 24 million[47], reflecting the limited modal shift for both passenger and freight noted above. This is equivalent to between 0.03% and 0.04% of the total emissions generated by transport activity in all Member States in 2017.[48]

Moreover, we suggest that the option is unlikely to contribute significantly to the better integration of national and urban transport systems needed to enhance connectivity for EU citizens and materially improve the quality of life for the growing proportion of the European population living in cities. Delivery of more integrated, higher quality urban transport services will depend critically on the participation of sponsors and operators of such services as well as suppliers of equipment and supporting systems. More generally, better integration of different transport modes will depend on the involvement of national rail operators, infrastructure managers and other transport service providers who can help coordinate the R&I activity needed to identify improvements in the interface between national and local networks. For the reasons already discussed, such participation would be limited in circumstances where support for R&I was restricted to open calls.

Option 1: Co-Programmed

We estimate a net reduction in CO_2 emissions of between 1.0 and 1.4 million tonnes in 2031, valued at €50 – 68 million. This is approaching three times the reduction achieved

[47] Carbon is valued at €48 per tonne, based on Handbook of External Costs of Transport 2014.

[48] Total CO_2 emissions from transport in Europe were 1,249.9 million tonnes in 2017 – see European Commission (2019c), Statistical Pocketbook, EU transport in figures, page 125, available at: https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2018_en.

under the baseline but still small when set against total emissions from transport in a single year.

Moreover, in our view this form of partnership would not encourage the level of participation from urban transport operators and other stakeholders needed to transform transport systems within and between cities. While in principle urban operators might be willing to be involved in projects investigating ways to improve the efficiency and attractiveness of tram and metro systems, it would be difficult to secure their support for the substantial demonstration activity required to encourage market take-up of innovation. More generally, in view of the likely disengagement of national infrastructure managers and other organisations capable of accessing substantial in-kind resources, the overall level of R&I effort directed towards this or any other area would be likely to fall relative to the level achieved under Horizon 2020.

In the absence of a transformation of the quality of national and urban transport systems, EU citizens would not benefit from the substantial improvements in connectivity described in *Section 4.3.3*. Access to jobs, educational opportunities and leisure facilities would therefore be less than might otherwise be the case, and the contribution of rail-related R&I to the creation of a people-centred economy and SDG 11 (Sustainable Cities and Communities) correspondingly limited.

Option 3: Institutionalised Art 187

The reduction in CO_2 emissions is likely to be more substantial under an institutionalised partnership as significantly more traffic would be diverted to rail from other, less environmentally friendly, modes. We estimate the reduction to be between 2.5 and 4 million tonnes in 2031, equivalent to up to 0.3% of total emissions from European transport in 2017. This impact could be expected to increase if the competitiveness of rail services continued to improve beyond the period of Horizon Europe.

We also consider that an institutionalised partnership would be more likely to deliver the transformational change to national and urban transport systems needed to enhance the connectivity enjoyed by EU citizens and improve the quality of the environment in European cities. For example, given the funding framework, wider participation and greater coordination of R&I activity previously discussed, the partnership would be better placed to develop a strategic programme of work designed to deliver material innovations in urban transport, drawing on input from urban operators and relevant transport authorities as well as the RSI. As in the case of other areas of rail-related R&I, market take-up would depend on programming demonstration projects that provided firm evidence of the benefits of innovation to operators and funders of urban services. It would also require the development of criteria for participation that did not involve an onerous commitment of resources.

Stakeholders responding to the **OPC** were not asked explicitly about which options would be likely to deliver the greatest societal impacts. However, as previously noted a majority of different stakeholder groups considered the societal impacts of a partnership to be relevant or very relevant.

For the most part, stakeholders participating in the **interview programme** and providing **feedback on the inception impact assessment** considered that an institutionalised partnership would be best-placed to deliver a range of beneficial societal impacts, including a reduction in environmental emissions and better integration of the European transport system in the interest of EU citizens. Again, they tended to highlight the importance of factors such as the need for a long-term strategy, coordination of contributions from a wide range of stakeholders and effective leverage of EU funding in achieving societal objectives.

Summary

Table 15 shows the scores for societal impacts that we have assigned to each of the policy options.

Table 15: Overview of the options' potential for achieving societal impacts

	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 3: Institutionalised Article 187
Reduction in environmental impacts of transport	+	++	+++
Improvements in safety, security and health of EU citizens	+	+	+++

Notes: Score +++: Option presenting a *high* potential; Score ++: Option presenting a *good* potential; Score +: Option presenting a *low* potential

6.2 Assessment of coherence

6.2.1 Internal coherence

In this section, we assess the extent to which the policy options have the potential to ensure coherence with other programmes and initiatives under Horizon Europe, in particular European Partnerships.

Option 0: Horizon Europe calls (baseline)

In our view, while some coordination of the activity described in *Section 4.4.1* could be achieved under the baseline option, it would be difficult to ensure an effective progression of activity from fundamental research through development work to demonstration. This is a consequence of the difficulty of ensuring continuity between projects at different TRLs under an open calls approach, not least because the parties responding to individual calls would typically be consortia formed on an ad hoc basis with limited knowledge of the broader strategic programme of R&I activity.

Similarly, coordination of R&I programmes with other initiatives, including any partnerships formed under the Climate, Energy and Mobility cluster or more generally under Horizon Europe, would be challenging. This is because there would be no single organisation accountable for the development of a strategy for rail-related R&I and capable of having a dialogue with other partnerships to identify potential synergies and joint activity. Rather, the Commission would need to consider the schedule of activity proposed by such partnerships alongside rail industry priorities in formulating the annual work programme. This would result in a significant risk of misaligned activity and duplicated effort, especially if joint R&I activity were to be programmed over several years.

Option 1: Co-Programmed

While the memorandum of understanding underpinning a co-programmed partnership would provide a vehicle for developing a strategic research agenda, development and delivery of the work programme would rely on Commission resources, with Member States approving Union contributions under comitology procedures. Hence, the partnership would not have full accountability for the direction of rail-related R&I and it would be difficult for

it to work with other partnerships within Horizon Europe to define an integrated work programme leveraging synergies in relevant areas. The risks of misalignment of projects and duplication of effort within the Climate, Energy and Mobility and other clusters would therefore arise in a similar way as in the baseline option, although they would be mitigated to some extent.

Option 3: Institutionalised Art 187

An institutionalised partnership would meet the functionality requirements described in *Section 4.4* more effectively and would therefore be better placed to deliver a more coherent long-term strategy for rail-related R&I. In particular, it would be able to call on dedicated management resources to develop the strategy and plan supporting work programmes in collaboration with other partnerships. It would also have a chief executive able to speak on behalf of the rail R&I community, broadly defined, in discussions about synergies and joint working. This would ensure that the strategy could take account of links with key partnerships both within and outside the Climate, Energy and Mobility cluster and provide for joint sponsorship of research in areas such as digital and battery and fuel cell technology and MaaS.

In responding to the **OPC**, a majority of stakeholders stated that the legal structure underpinning an institutionalised partnership was either relevant or very relevant to the facilitation of collaboration with other partnerships under Horizon Europe. Support for this view was particularly strong among large business organisations and business associations, but it was also held by most SMEs, academic and research institutions, public authorities and EU citizens. A substantial majority in each of the same stakeholder groups confirmed that there would be scope for rationalising the activities of the candidate partnership for rail and to link it with other initiatives under Horizon Europe.

Stakeholders participating in the **interview programme** indicated that a future partnership would be able to cooperate more with other initiatives under Horizon Europe to leverage the benefits of technology that is not specific to the rail sector. One regulatory agency stressed the importance of developing a strategy and work programme that reflected the needs of a fully integrated transport system for Europe, although there was little support for a radical rationalisation of sector-focused partnerships. The S2R JU already collaborates with other partnerships and believes this should continue under Horizon Europe.

For the most part, stakeholders providing **feedback on the inception impact assessment** did not express particular views on internal coherence, although some noted the importance of taking account of activities undertaken by under other European initiatives.

6.2.2 External coherence

In this section we assess the extent to which the policy options have the potential to ensure coherence with EU-level programmes and initiatives beyond the Framework Programme and/or national and international programmes and initiatives.

Option 0: Horizon Europe calls (baseline)

It would be difficult to coordinate the development of a work programme taking account of parallel, related activity under the DEP or funded under CEF, ERDF or CF. Effective coordination would require a strong, dedicated central planning capability, which, in our view, could not be provided by the Commission infrastructure planning open calls on an annual basis.

Option 1: Co-Programmed

The barriers to coordination within Horizon Europe would extend to coordination with other programmes under DEP, CEF, ERDF and CF. While the creation of a vehicle for developing a strategy and planning activity under a memorandum of understanding would provide a mechanism for the necessary collaborative dialogue, the inability of the partnership to ensure the direction of R&I activity would make it difficult to commit to joint programmes of work. Even if such programmes could be agreed in principle, there could be no guarantee that work undertaken in response to open calls would be fully aligned with the specification of activity anticipated under other funding initiatives.

Option 3: Institutionalised Art 187

By contrast, an institutionalised partnership would be able to explore opportunities for funding of programmes and projects under DEP, CEF, ERDF and CF and fully commit to collaborative working. It would also be able to represent the interests of the rail R&I community in discussions with other relevant European institutions, for example the European Investment Bank. More generally, as the partnership would be more visible than either of the other options, it would be likely to facilitate links with a wider range of EU institutions, agencies and initiatives. This would support more efficient use of overall EU funding of transport projects and potentially lead to even wider participation in the R&I programme for rail.

Echoing the views expressed in respect of internal coherence, a majority of the stakeholders responding to the **OPC** considered that establishing a specific legal structure for the candidate European Partnership was either relevant or very relevant to the facilitation of synergies with other EU and national programmes. This view was particularly strongly held by the larger business organisations and business associations as well as by EU citizens. **Interviewees** also expressed the view that a future partnership would be well-placed to develop a dialogue with other EU initiatives, notably CEF, and that it could facilitate opportunities for collaborative funding using sources outside the scope of Horizon Europe. A limited number of the stakeholders providing **feedback on the inception impact assessment** suggested that an institutionalised partnership would be better able to take account of the activities of other, relevant EU agencies and organisations and to explore the potential for support for R&I from CEF.

Summary

Table 16 shows the scores that we have assigned to each of the policy options in respect of coherence.

Table 16: Overview of the options' potential for achieving coherence

	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 3: Institutionalised Article 187
Internal coherence	+	+	+++

	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 3: Institutionalised Article 187
External coherence	+	+	+++

Notes: Score +++: Option presenting a *high* potential; Score ++: Option presenting a *good* potential; Score +: Option presenting a *low* potential

6.3 Comparative assessment of efficiency

In order to compare the policy options under common standards, we developed a standard cost model for all 13 candidate institutionalised partnership studies. The model and the underlying assumptions and analyses are set out in the report on the overarching context to the impact assessment studies. *Table 17*, below, shows the intensity of additional costs against specific cost items for the various options as compared to the baseline (Option 0 - Horizon Europe calls). In this table we have recognised that for Option 3 (institutionalised partnership) there would be moderate additional costs for the set-up of a dedicated implementation structure as such a structure already exists. For Option 1 (co-programmed), we did not consider an additional cost for the call and project implementation as Member States would not be providing contributions.

Table 17: Intensity of additional costs compared with HEU Calls (for Partners, stakeholders, public and EC)

Cost items	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 3: Institutionalised Article 187
Preparation and set-up costs			
Preparation of a partnership proposal (partners and EC)	0	++	++
Set-up of a dedicated implementation structure	0	0	++
Preparation of the SRIA / roadmap	0	++	
Ex-ante Impact Assessment for partnership	0	0	+++
Preparation of EC proposal and negotiation	0	0	+++
Running costs (Annual cycle of implementation)			
Annual Work Programme (AWP) preparation	0	+	+
Call and project implementation	0	0	+
Cost to applicants	0	0	0
Partners costs not covered by the above	0	+	+
Additional EC costs (e.g. supervision)	0	+	++

Cost items	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 3: Institutionalised Article 187
Winding down costs			
EC	0	0	+++
Partners	0	+	+

Notes: 0: no additional costs, as compared with the baseline; +: minor additional costs, as compared with the baseline; ++: high additional costs, as compared with the baseline; +++: very high additional costs, as compared with the baseline

The scores related to the costs set out above allow for a "value for money" analysis (cost-effectiveness) in the final scorecard analysis in *Section 6.4*. For this purpose, in Table 18 we provide the scores for the scorecard analysis, based on our insights and findings above, with a score of 1 assigned to the option with the highest costs and a score 3 to that with the lowest.

Table 18: Matrix on 'overall costs' and 'cost-efficiency'

	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 3: Institutionalised
Overall cost	3	2	1
Cost-efficiency	3	3	2

Notes: Score 1 = Substantial additional costs, as compared with the baseline; score 2 = Medium additional costs, as compared with the baseline; score 3 = No or minor additional costs, as compared with the baseline

We consider that while there is a clear gradation in the overall costs of the policy options, the cost differentials are less marked when we take account of financial leverage (co-financing rates) and the total budget available for each of the policy options, assuming a common Union contribution. From this perspective, there are only one or two percentage points that separate the most cost-efficient policy options – the baseline Option 0 and the co-programmed policy options – and the least cost-efficient – the institutionalised partnership. We have therefore assigned a score of 3 for cost-efficiency to the baseline and the co-programmed policy options and a score of 2 for the institutionalised partnership.

We note that the potential for the creation of crowding-in effects for industry has been taken into account when assessing the effectiveness of the policy options.

6.4 Comprehensive comparison of the options and identification of the preferred option

Building on the previous analysis, this section presents a comparison of the options' 'performance' against the three dimensions of effectiveness, efficiency and coherence.

In *Section 6.4.1*, we first compare the policy options against each other for each criterion in the effectiveness and coherence dimensions, resulting in a scorecard with scores from 1 to 3 where 3 stands for a substantially higher performance. Combined with the results from the comparative assessment for efficiency in *Section 6.3*, above, the final scorecard

allows for the identification of the preferred option in *Section 6.4.2*, taking all dimensions and criteria into account.

6.4.1 Comparative assessment

Effectiveness

A co-programmed partnership would result in a greater number of high-quality jobs in rail-related R&I than open calls since it would enable R&I activity to be programmed more effectively and encourage somewhat wider participation among stakeholders. However, in our view its contribution to the pipeline of potential innovation over the long term would not be materially greater as participation would not be sufficient to support adequate demonstration activity, resulting in limited market focus. An institutionalised partnership would provide the legal framework and dedicated administrative structure necessary to encourage much wider participation, thereby improving the leverage of EU funding (and hence the level of available resources) and ensure better coordination of R&I projects at different TRLs. The creation of high-quality jobs and strengthening of the innovation pipeline under this option would therefore be substantially greater.

Given greater involvement of stakeholders from both the RSI and rail transport industry under a co-programmed partnership than under open calls alone, the former could be expected to result in higher market take-up of R&I outputs, leading to an improvement in the competitiveness of both European rail services and rail equipment and systems exported by the RSI. However, under an institutionalised partnership there would be much greater involvement of stakeholders from across the rail industry as well as from SMEs and technology-based organisations located in other sectors, enabling a significantly higher level of market-focused development and demonstration projects and hence a substantially higher level of market take-up. This would translate into a material improvement in rail's modal share of passenger and freight transport markets and in the RSI's competitiveness over the period of Horizon Europe, leading to greater increases in rail sector and other employment.

The greater modal shift in favour of rail under an institutionalised partnership would be reflected in a significantly greater reduction in CO_2 and other environmental emissions compared to the other options, although we would also expect some reduction under a co-programmed approach. More generally, the societal impacts of each option would depend critically on the extent of participation of stakeholders able to support projects focused on better integration of passenger and freight transport services. In particular, the participation of urban transport operators, providers of freight transport and logistics services and port operators would be essential if the initiative was to help improve connectivity and the broader quality of life for EU citizens. For the reasons given above, we consider that an institutionalised partnership would be better placed to ensure an appropriate profile of participation and develop an R&I strategy aligned with EU societal objectives than a co-programmed partnership, although the latter would deliver greater societal benefits than open calls.

Coherence

A co-programmed partnership would provide a platform for developing a more coherent programme of rail-related R&I than a purely open calls approach. This would enable better coordination and leveraging of potential synergies with both other partnerships under Horizon Europe and other EU institutions and initiatives providing funding for the European rail sector. However, as the administration of the programme would be based on open calls, it would be difficult to offer the level of commitment needed to ensure effective collaboration in specific areas of R&I relevant to other partnerships.

By contrast, an institutionalised partnership would have the administrative structure needed to develop a long-term strategy for R&I and supporting work programme that took

full account of the corresponding programmes of other partnerships. This would enable it to identify and commit to opportunities for collaboration that made efficient use of EU funding while supporting the achievement of common policy objectives. In addition, by providing a single voice for the rail sector on issues related to R&I, it could facilitate discussions with funding initiatives, policy makers, standards bodies and other regulatory organisations at the international and national levels more effectively than a co-programmed partnership. A ranking of the policy options is presented in the table below.

Table 19: Ranking of the policy options

	Items	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 3: Institutionalised Article 187
Effectiveness	Scientific impacts – increase in high quality jobs	1	2	3
	Scientific impacts – strengthened pipeline of potential innovation	1	1	3
	Technological/economic impacts – increase in rail's modal share	1	2	3
	Technological/economic impacts – increase in RSI competitiveness	1	1	3
	Technological/economic impacts – increase in total employment	1	1	3
	Societal impacts – reductions in environmental impacts	1	2	3
	Societal impacts – improvements in safety, security and health	1	1	3
Coherence	Internal coherence	1	1	3
	External - coherence	1	1	3
Efficiency	Overall cost	3	2	1
	Cost-efficiency	3	3	2

Notes: Scores for effectiveness and coherence: 3 = *substantially higher performance*; 2 = *higher performance*; 1 = *lower performance*. Scores for efficiency: 1 = *substantial additional costs*, as compared with the baseline; 2 = *medium additional costs*, as compared with the baseline; 3 = *No or minor additional costs*, as compared with the baseline

6.4.2 Identification of the preferred option

The table shows that the baseline option of open calls under Horizon Europe performs poorly in all dimensions except efficiency, a reflection of the difficulties of developing a long-term strategy supported by a wide range of relevant stakeholders under this approach. The higher scores for efficiency are due to the option's reliance on the Commission's common framework for administering open calls, which effectively spreads the cost of administration across a number of initiatives under Horizon Europe.

The co-programmed partnership, which is similarly dependent on open calls administered under a common framework, also performs poorly against many criteria, particularly those for which the corresponding impact is critically dependent on participation and commitment

of resources on the part of key stakeholders. However, in our view it is likely to perform better than the baseline option in creating high quality jobs, increasing rail's share of transport markets and reducing environmental impacts, at least at the margin, since it would enable the development of a work programme broadly aligned with market needs and EU policy objectives.

However, the institutionalised partnership dominates all dimensions apart from efficiency and is therefore our preferred option. This is principally because it would enable the development of a work programme based on a long-term strategy for R&I while encouraging participation from key stakeholders with access to significant financial and in-kind resources that they would be willing to commit under a clearly defined legal framework. Moreover, while it performs less well in terms of overall cost, it is only marginally less cost-efficient than the other options.

7 The preferred option

7.1 Description of the preferred option

Based on the results of the assessment described in the previous chapter, we conclude that an institutionalised partnership established under Article 187 of TFEU is the preferred option. This is in line with the need to ensure that private sector and commercially focused entities from both the RSI and the rail transport industry are fully engaged in the development and implementation of a long-term strategy for rail-related R&I. More generally, it meets the functionality requirements set out in *Section 4.4* particularly effectively by:

- Facilitating the development of a strategy that is fully aligned with the completion of SERA as well as a number of SDGs and the political priorities identified by the new President of the Commission;
- Providing a stable framework for encouraging the participation of organisations from different stakeholder groups, including SMEs and organisations outside the rail industry;
- Leveraging industry financial and in-kind resources such that the impact of funding provided by the Commission is maximised;
- Providing for the effective management of a wide range of R&I projects across the TRLs, encouraging a high level of market take-up of outputs;
- Facilitating relationships with other partnerships and initiatives within the Climate, Energy and Mobility cluster and other EU initiatives; and
- Enabling effective dialogue with national and international standards bodies, Member States and third countries.

In *Table 20* we indicate the extent to which the partnership would meet the criteria identified in Annex III of the Commission proposal for the Horizon Europe Regulation. Since the design of the candidate institutionalised partnerships is not yet concluded, and several related issues are outstanding at the time of writing, our conclusions in respect of additionality/directionality and long-term commitment are based on expectation.

Table 20: Alignment with the selection criteria for European Partnerships

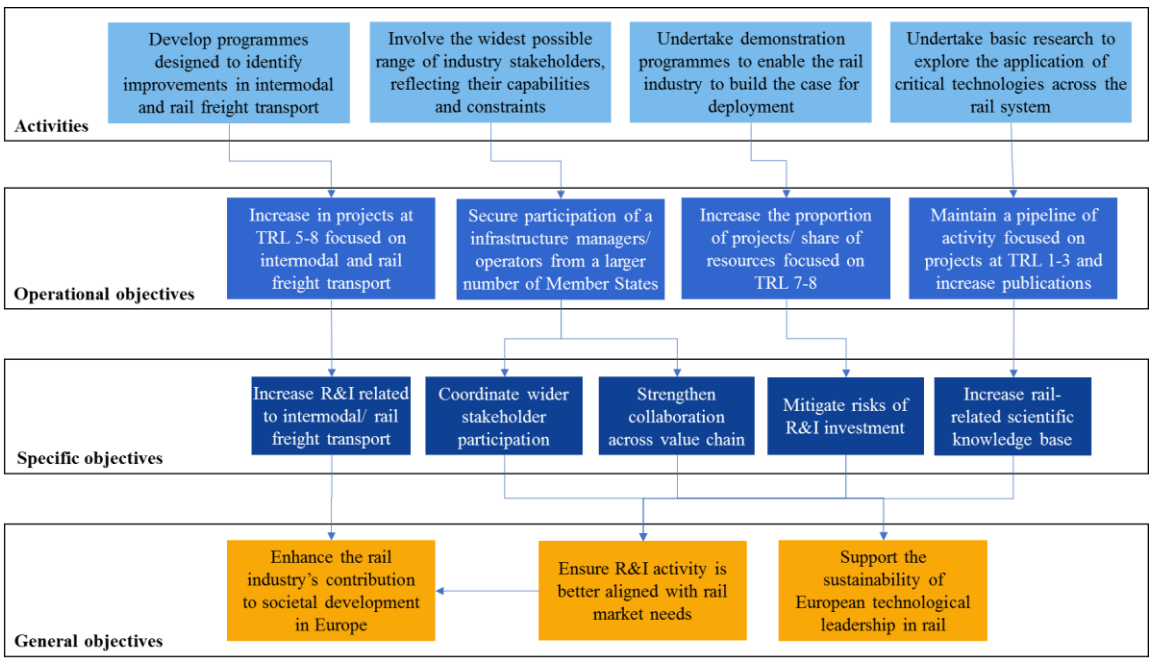
Criterion	Alignment of the preferred option
Higher level of effectiveness	As demonstrated in Section 6, an institutionalised partnership would be considerably more effective in improving the competitiveness of both the rail transport industry and RSI, since it would ensure that a substantially higher proportion of R&I outputs would be taken up by the market than under other options.

Criterion	Alignment of the preferred option
Coherence and synergies	A dedicated management team responsible for the development of a long-term strategy and supporting work programmes for rail-related R&I could ensure that these were fully integrated with relevant strategies and programmes developed by other partnerships and initiatives. This would enable the better exploitation of synergies from joint programmes and projects, for example in areas such as digital, battery technology and MaaS.
Transparency and openness	An institutional partnership would ensure that the outputs of R&I programmes were as transparent and available to stakeholders inside and outside the rail industry as possible while providing appropriate protection for intellectual property. The framework governing participation would provide for initial calls for members, attaching conditions relating to the provision of funding and a commitment to supporting EU rail policy objectives. The management of activities, in particular the role of open calls, would be subject to further consideration.
Additionality and directionality	The partnership could be expected to develop a long-term strategy for rail-related R&I, in consultation with stakeholders inside and outside the rail industry and establish a set of common objectives governing the direction of R&I activity under Horizon Europe. This would be more focused on industry and market needs than would be the case under other options.
Long-term commitments	The partnership would also encourage long-term commitment of financial and in-kind resources from infrastructure managers and other stakeholders with access to significant levels of internal funding for R&I activity. Hence, we would expect the partnership to ensure a minimum share of investment from private sector and other commercial stakeholders, with at least 50% and possibly up to 75% of the budget coming from this source.

7.2 Objectives and corresponding monitoring indicators

7.2.1 Operational objectives

Figure 8: Operational objectives of the initiative



The figure above identifies a broad range of actions and activities, beyond the R&I activities that can be implemented under Horizon Europe. This reflects the definition of European

Partnerships in the Horizon Europe Regulation as initiatives for which the Union and its partners "commit to jointly support the development and implementation of a programme of research and innovation activities, including those related to market, regulatory or policy uptake."

7.2.2 Monitoring indicators

We have identified a number of short, medium and long-term monitoring indicators to enable the progress of the partnership towards meeting its objectives to be tracked, as shown in Table 21.

Table 21: Monitoring indicators in addition to the Horizon Europe key impact pathway indicators

	Short-term (typically as of year 1+)	**Medium-term (typically as of year 3+)**	**Long-term (typically as of year 5+)**
Scientific impact – increasing rail-related scientific knowledge base	Number of projects resulting in one or more publications	Number of times that publications generated by the partnership are cited in the global literature	Number of patents and industrial designs registered by suppliers of railway equipment and systems based in Europe
Scientific impact – increasing rail-related scientific knowledge base	Number of individuals working on projects initiated by the partnership	Number of occupied and advertised jobs in rail-related R&I	Number of staff transferring between research-based institutions and the rail industry
Technological / economic impact – wider stakeholder participation	Number of programmed projects involving SMEs and/or organisations outside the rail industry	Number of projects considered to have strong market take-up (based on Foster Rail criteria)	Rail's modal share of passenger and freight transport markets
Technological / economic impact – strengthened collaboration	Number of programmed projects at TRLs 1 – 3 with a documented strategy for progressing to TRLs 4 - 7	Number of projects considered to have strong market take-up (based on Foster Rail criteria)	European RSI's share of global markets
Technological / economic impact – mitigate risks of R&I investment	Number of programmed demonstration projects	Level and intensity of rail sector R&I	Direct and indirect employment generated by the European rail sector
Environmental / sustainability impact	Number of programmed projects developing technological applications for rail freight	Number of projects relevant to rail freight considered to have strong market take-up (based on Foster Rail criteria)	Changes in CO_2 emissions generated by freight transport
Social impact	Number of programmed projects developing technological applications for urban transport	Number of projects relevant to urban transport considered to have strong market take-up (based on Foster Rail criteria)	Modal share of tram and metro Changes in air quality and traffic accidents in European cities

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Appendix B Synopsis report on the stakeholder consultation – Focus on the candidate European Partnership on Transforming Europe's Rail System

Disclaimer: the views expressed in the contributions received are those of the respondents and cannot under any circumstances be regarded as the official position of the Commission or its services.

B.1 Introduction

Following the European Commission's proposal for Horizon Europe in June 2018,[49] 12 candidates for institutionalised partnerships within 8 partnership areas have been proposed, based on the political agreement with the European Parliament and Council on Horizon Europe reached in April 2019.[50] Whether these proposed institutionalised partnerships will go ahead in this form under the next research and innovation programme is subject to an impact assessment.

In line with the Better Regulation Guidelines[51], the stakeholders were widely consulted as part of the impact assessment process, including national authorities, the EU research community, industry, EU institutions and bodies, and others. These inputs were collected through different channels:

- A feedback phase on the inception impact assessments of the candidate initiatives in August 2019,[52] gathering 350 replies for all 12 initiatives;
- A structured consultation of Member States performed by the EC services over 2019;
- An online public stakeholder consultation administered by the EC, based on a structured questionnaire, open between September and November 2019, gathering 1635 replies for all 12 initiatives;
- A total of 608 Interviews performed as part of the thematic studies by the different study teams between August 2019 and January 2020.

This document is the synopsis report for the initiative "Transforming Europe's Rail System". It provides an overview of the responses to the different consultation activities. A full analysis of the results is provided in the study Data Report.

[49] https://ec.europa.eu/commission/presscorner/detail/en/IP_18_4041

[50] https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_19_2163

[51] https://ec.europa.eu/info/files/better-regulation-guidelines-stakeholder-consultation_en

[52] The full list of inception impact assessments is available here. They were open for public feedback until 27 August 2019.

B.2 Feedback to the inception impact assessment on candidate initiatives for institutionalised partnerships

Following the publication of the inception impact assessment, a feedback phase of 3 weeks allowed any citizen to provide feedback on the proposed initiatives on the "Have your say" web portal. In total 350 feedbacks were collected for all initiatives.

For the initiative "Transforming Europe's Rail System" 46 individual feedbacks were collected, mainly from companies and business organisations.[53] Among the elements mentioned were:

- The importance of rail-related R&I in enhancing the role of rail in an integrated and sustainable European transport system, and the potential for rail to compete for passengers currently using air transport through easier planning of journeys using several modes, more competitive journey times, better management of service disruption and higher quality on-board service;
- The need to reinforce Europe's technological leadership in rail (an issue highlighted by both business and academic/research organisations);
- The impact of industry fragmentation in limiting the level of R&I in the rail sector and the critical need to increase market take-up of new products and services;
- The need for EU action to address the issue of fragmentation and other factors tending undermine the extent and effectiveness of rail-related R&I;
- The key role of the rail sector in supporting EU societal objectives, in particular action to limit the impact of climate change through encouraging use of more environmentally friendly modes of transport such as rail;
- Strong endorsement of rail's potential contribution to broader scientific, technological and economic development across Europe; and
- Strong support for an institutionalised partnership capable of developing a long-term strategy for both fundamental research and market-focused innovation in the rail sector.

B.3 Structured consultation of the member states on European partnerships

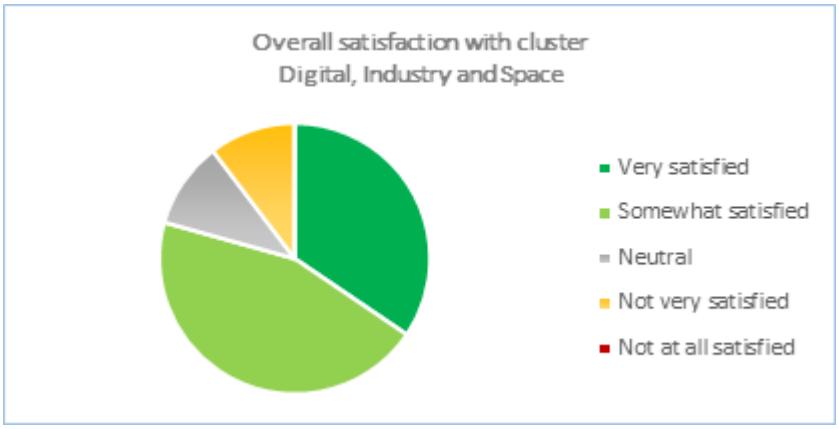
A structured consultation of Member States through the Shadow Strategic Configuration of the Programme Committee Horizon Europe in May/June 2019 provided early input into the preparatory work for the candidate initiatives (in line with the Article 4a of the Specific Programme of Horizon Europe). This resulted in 44 possible candidates for European Partnerships identified as part of the first draft Orientations Document towards the Strategic Plan for Horizon Europe (2021-2024), taking into account the areas for possible institutionalised partnerships defined in the Regulation.

The feedback provided by 30 countries (all Member States, Iceland and Norway) has been analysed and summarised in a report, with critical issues being discussed at the Shadow Strategic Programme Committee meetings.

The thematic coverage for the Cluster Climate, Energy and Mobility is perceived as rather satisfying, with 62% being somewhat satisfied and 10% very satisfied, while 7% each are not very satisfied or not satisfied at all.

[53] Feedback on inception impact assessment to be found on https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2019-4980251/feedback_en?p_id=5722806

Figure 9: Satisfaction with the thematic coverage of the proposed partnership portfolio for the Digital, Industry and Space cluster



Many delegations comment on the balance of topics and suggest a stronger focus on the environment and climate, as well as energy topics. Mobility is considered too prominent and should be rationalised further. The area of transport in particular appears to have a disproportionate number of partnerships, which may result in an underinvestment for open calls in this area.

The high number of individual partnerships could jeopardise the ambitious targets to reach the climate neutrality for 2050. Emphasis should be placed on the need to promote cross-sectorial solutions for decarbonization. Cross-sector solutions, or solutions for coupling of different energy vectors will be difficult to implement if each partnership works in silos. Synergies will be difficult to implement since there is a risk that each initiative will defend its own interests. Openness and a clear path to membership for interested parties is essential for the industry partnerships to have true European Added Value.

A majority of countries support additional priorities to be implemented by partnerships, notably the following two:

- Partnership on European Climate Change Science would the Paris Agreement, in recognition of the need for scientific understanding of climate change as basis to reduce vulnerability and enhance resilience. It would address in a structured and integrated manner key uncertainties regarding Earth system sciences and model development as well as the effectiveness of policy interventions and societal response to climate change. It will address both structural and operational gaps.
- Partnership on Sustainable and Liveable Cities and Communities, with a holistic approach to make a substantial contribution towards the urban dimension of the SDGs and the Urban Agenda of the EU. I would aim at creating an innovation eco-system for cities to drive urban transitions, create evidence with and for urban stakeholders to achieve urban-related SDGs and position European cities as role models for global sustainable development.

In addition, few delegations propose an additional partnership related to transport, for the waterborne sector, mainly with the argument that this is the only transport mode not covered by a partnership.

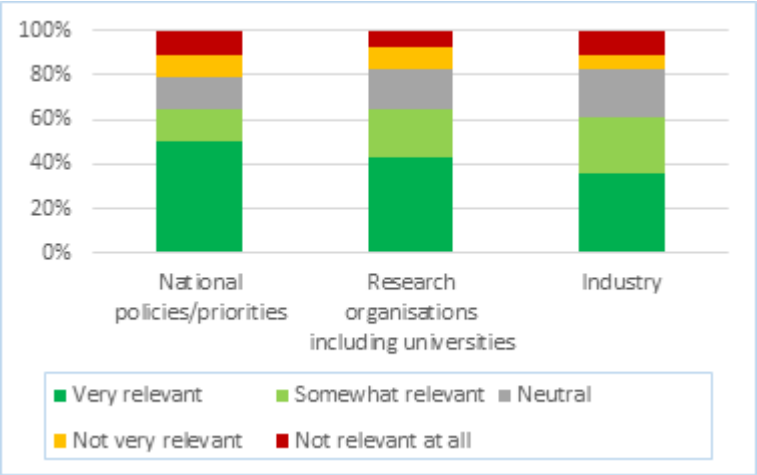
B.3.1 Overall feedback for the initiative "Transforming Europe's Rail System"

Relevance and positioning in a national context

The feedback from countries suggest that the proposed European Partnership for Transforming Europe's rail system is to a large extent relevant, with 64% considering it relevant for their national policies and priorities and for their research organisations,

including universities, and slightly less (61%) consider it very relevant or somewhat relevant for their industry.

Figure 10: Relevance of the European Partnership for Transforming Europe's rail system in the national context



On the question of existing national/regional R&I strategies, plans and/ or programmes in support of the proposed Partnership, 18 countries report to have relevant elements in place. National economic, sectoral strategies and/or plan with a strong emphasis on research and/or innovation (57%, AT, DE, ES, FR, HR, IT, LV, NL, PL, RO, SE, SI, SK, UK, NO) and R&I strategies or plans (54%, AR, CZ, DE, ES, FR, HR, IT, LV, NL, PL, RO, SE, SI, UK, NO) were identified most frequently. Countries reported to a lesser extent to having dedicated R&I funding programmes or instruments (32%, AT, CZ, DE, ES, HR, LUX, PL, SE, UK, NO) and regional R&I and/or smart specialisation strategies (25 %, ES, FR, HR, PL, RO, SE, SI). 5 countries (CZ, FR, HR, IE, SE) reported other policies/ programmes.

Delegations identified a number of aspects that could be reinforced in the proposal that would increase its relevance for national priorities.19 Notably, countries from Central and Eastern Europe stress the need to focus more on deployment and piloting to transform the results of the partnership into real world solutions, and in this context also to ensure synergies with related policies, and investments at national and EU level (e.g. CEF, Cohesion Funds). Other comments suggest the need to adjust the scope of the proposed partnership and focus more on integrating alternative energy solutions (hydrogen, batteries), digitalisation of the existing system, robotisation for maintenance, ensuring a holistic approach to the railways system including infrastructure and maintenance, and developing user-centred innovations.

The majority of countries (57%) are undecided concerning their interest to participate as a partner. At this stage 8 countries (CZ, DE, ES, IT, NL, PL, SE, UK) express an interest to join as a partner, and 3 countries (CY, EE, IS) express there is no national interest to participate.

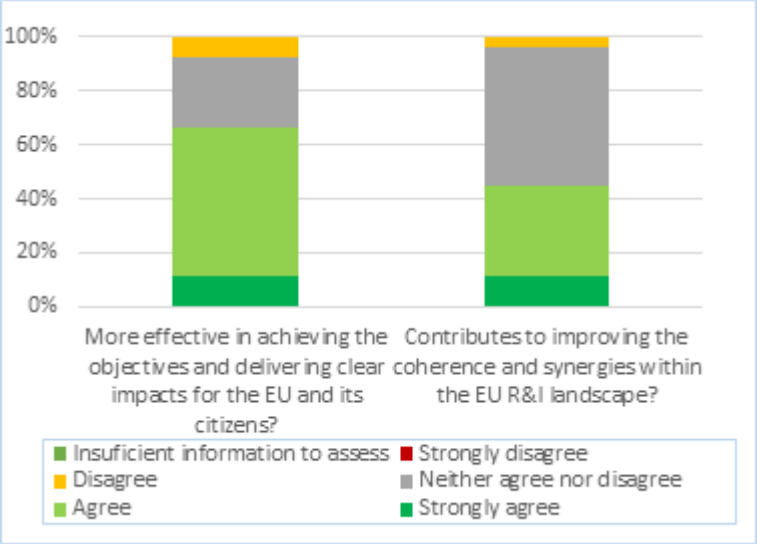
Most frequently identified possible elements for participation are existing national R&I programmes (39%), 32% with planned R&I programmes, followed by governmental research organisations (36%), research infrastructures (29%) and regional R&I and/or smart specialisation strategies (29%). The additional comments on the interest to join indicate that there is need to clarify the role of the public in this partnership, and expectation to ensure alignment with national policies, programmes and investments in rail system at early stage of preparing the partnership.

The majority of the countries (86%) express interest in having access to results produced in the context of the partnership.

Feedback on objectives and impacts

There is good agreement (60%) on the use of partnership approach for Transforming Europe's Rail System, whilst quarter of respondents remain neutral. The majority of delegations (65%) agree that the partnership is more effective in achieving the objectives and delivering clear impacts for the EU and its citizens, but to a lesser degree (43%) that it would contribute to improving the coherence and synergies within the EU R&I landscape.

Figure 11: Agreement on arguments for a Partnership for Transforming Europe's rail system in delivering impacts, improving coherence and synergies



The feedback from countries indicate there is a good agreement with the proposed objectives at short, medium and long term, with 78% either agree or strongly agree, and the rest remaining neutral. 64% of countries consider the impacts very or somewhat relevant in the national context. The vast majority of responses (79%) suggest that the envisaged duration of the proposed partnership is adequate. Individual comments made by delegations highlight the relevance of the topic, in particular the need for system-wide R&I to overcome a fragmented sector. They also reiterate several points made previously under elements to be reinforced to increase relevance, notably to include clean propulsion solutions, and strengthen synergies with related EU and national programmes. In addition, it is suggested to broaden the scope by including aspects related to social geography (human displacements, multimodality, cross-border rail) and international transport (including high speed and intermodal solutions).

Views on partners, contributions and implementation

Slightly more than half (54%) of the responses agree on the type and composition of partners, whilst 25% remain neutral and 2 countries disagree. Additional comments suggest several countries wish to see an increased role of Member States, as well as openness towards new and smaller partners.

At this stage, most countries (64%) would need more information on the contributions and level of commitments expected from partners. Additional comments highlight the need to ensure synergies with Cohesion Funds and CEF for exploitation and uptake of innovation.

At this stage there is no clear agreement on the proposal to implement the proposed partnership based on the Article 187 TFEU - 46% of countries wish for more details to make an informed decision, 36% agree and 18% disagree. Individual comments made by delegations suggest dissatisfaction with the big number of Article 187 TFEU partnership proposals in the area of transport, with the insufficient transparency and openness of the Joint Undertaking (JU) model, as well as with the mode-specific approach in mobility. It is thus, suggested to analyse whether the objectives of this proposal could be reached with

alternative implementation modes, notably the co-programmed model; if not, then countries wish to see a considerable reform in the set-up of the JU. The feedback stresses the need to allocate Union funding through open calls for proposals (subject to comitology).

B.4 Targeted consultation of stakeholders related to the initiative "Transforming Europe's Rail System"

In addition to the consultation exercises coordinated by European Commission services, the external study thematic teams performed targeted consultations with businesses, research organisations and other partners on different aspects of potential European Partnerships.

The feedback obtained as part of this targeted consultation of stakeholders was used in the Impact Assessment study, as described in the approach section below, and was summarised in an Interview Summary Report which was developed and submitted alongside the Impact Assessment study Final Report.

B.4.1 Approach to the targeted consultation

The stakeholder interviews are a primary source of information that have informed all aspects of the impact assessment, complementing the analyses based on desk research and primary and secondary data. Specifically, it underpins:

- The selection and description of the policy options for the intervention;
- The comparative assessment of options: and
- The assessment of the preferred option in terms of its effectiveness and coherence as well as in relation to the key Criteria for European Partnerships (openness and transparency, additionality and directionality, Member State involvement, and systemic approach and flexibility).

Accordingly, the consultation exercise covered a wide range of organisations engaged in rail transport, the rail industry supply chain, research and education, as set out in the following section. In identifying stakeholders, we applied the following criteria:

- The need to discuss the role of a future partnership with key European bodies with a central role in the delivery of EU policy objectives, in particular the S2R JU itself, ERRAC and ERA;
- The need to engage with stakeholders located in all Member States with a railway and an interest in the future direction of rail-related R&I;
- The need to obtain views from both founding and associate members of the S2R JU, including manufacturers, infrastructure managers and train operators, who could provide insights into the costs and benefits of a partnership approach to sponsorship and coordination of R&I;
- The importance of understanding key developments in research through dialogue with universities and other research institutions engaged in pre-competitive R&I in the rail sector;
- The need to engage with organisations who have had little or no involvement in the existing JU but whose role in the delivery of integrated European rail services and in ensuring that the sector meets European economic, social and environmental targets is critical, notably freight and urban passenger transport operators as well as SMEs in the RSI;
- The importance of engaging with pan-European representative organisations able to provide an overview of the perspectives of specific stakeholder groups, for example the

RSI, infrastructure managers, national rail operators, urban transport operators and passengers; and

- The need to involve organisations operating outside the rail industry but with a role in developing key technologies, such as digital and automation, with broad applications within rail and the transport sector more generally.

Accordingly, we developed the list of 50 stakeholders based on a number of potential organisations, in line with the following criteria:

- Coverage of the current members of Shift2Rail, both founding members and associates;
- Inclusion of organisations recommended by the European Commission, Shift2Rail and our expert panel; and
- Balancing the number of stakeholders by type of organisation and Member State.

The table below shows the balance of stakeholder organisations across these selection criteria and the rationale for their inclusion in the consultation.

Table 22: Overview of stakeholder interviews' methodology

Stakeholder group	S2R JU members?	Number in selection	Rationale
Key European bodies	N/A	3	An important perspective on R&I needs during Horizon Europe and beyond
Member State transport authorities	N/A	4	Can provide views on Member State participation and alignment of R&I policy with national objectives
Organisations in RSI	Yes	7	An important perspective on R&I needs An understanding of commercial issues surrounding rail-sector R&I An understanding of global markets
Research organisations and universities	No	10	Able to provide a perspective on contribution of fundamental research and most effective ways of collaborating with manufacturers and service providers
Infrastructure managers	Mixed	5	An important understanding of user requirements influencing the direction of R&I Perspectives on the efficiency and effectiveness of partnerships
National passenger rail operators	Mixed	7	An important understanding of user requirements influencing the direction of R&I Perspectives on the efficiency and effectiveness of partnerships
Urban transport operators	No	2	An important understanding of user requirements influencing the direction of

Stakeholder group	S2R JU members?	Number in selection	Rationale
			R&I, particularly in relation to integrated passenger transport
Rail freight operators/logistics companies	No	4	An important understanding of user requirements influencing the direction of R&I, particularly in relation to integrated freight transport
Pan-European representative organisations	N/A	7	Able to provide an informed overview of issues faced by key stakeholders
Non-rail technology organisations	No	1	Able to provide a view on potential role of cross-cutting technologies in transport

The final list of stakeholders was validated by the European Commission. We have interviewed the majority of stakeholders in this list; however, where they were not willing to contribute to the study or could not be contacted, candidates from a longer list approved by the European Commission were selected, maintaining the balance between types of organisation and Member States.

The topic guides for the stakeholder interviews were designed with the intention of guiding the stakeholder interviews. Note that they have not been used as a rigid script, but rather a prompt for interviewers seeking to ensure coverage of relevant issues. As far as possible, the questions were drafted as open questions to maximise the information provided and avoid unduly constraining the responses.

At the same time, it was important to ensure that the information obtained informed the analysis. Interviewers therefore sought to cover a range of relevant topics supporting specific elements of the impact assessment, as shown in the table below.

Table 23: Topics covered in stakeholder interviews

Topics	Issues	Description of policy options	Comparative assessment of policy options	Description of preferred option
Problems and objectives	• Validation of problem • Validation of objectives	✓		✓
Profile of participation	• Profile of participation required • Need for participation of specific players • Need for broader participation • Need for flexibility	✓	✓	✓

Topics	Issues	Description of policy options	Comparative assessment of policy options	Description of preferred option
Involvement of Member States	• Member States to involve (strength/critical mass/priorities) • Role of Member States	✓		✓
Target groups	• Key sectors to involve • Need for flexibility	✓	✓	✓
Activities	• R&I priorities • Definition and management of programmes • Need for flexibility	✓	✓	✓
Collaboration with other partnerships/ initiatives	• Scope/type of informal collaboration • Scope/type of formal collaboration • Synergies relationships between R&I programmes		✓	✓
Finance	• Level of investment required • Importance of long-term funding • Level of commitment required from partners • Level of commitment from Member States • Anticipated costs		✓	✓
Implementation	• Appropriate governance structure • Measures to ensure openness • Measures to ensure flexibility			✓

The table below describes the number of interviews undertaken by stakeholder category, as well as its proportion of the total.

Table 24: Number of interviews per stakeholder category

Stakeholder category	Number	Share (%)
Associations	9	18%
European body – regulatory agency	1	2%
Freight operators/supply chain	4	8%

Stakeholder category	Number	Share (%)
Infrastructure manager	5	10%
Member States' transport authorities	4	8%
Passenger operators	7	14%
Research and technologies organisations	5	10%
Research and technology organisation (non-rail)	1	2%
Third party industry suppliers	7	14%
Universities/academic bodies	5	10%
Urban passenger operators	2	4%
TOTAL	**50**	**100%**

B.4.2 Overview of respondents to the targeted consultation

The table below summarises the number of interviews undertaken by stakeholder category, as well as its proportion of the total.

Table 25: Number of interviews per stakeholder category

Stakeholder category	Number	Share (%)
Associations	9	18%
European body – regulatory agency	1	2%
Freight operators/supply chain	4	8%
Infrastructure manager	5	10%
Member States' transport authorities	4	8%
Passenger operators	7	14%
Research and technologies organisations	5	10%
Research and technology organisation (non-rail)	1	2%

Stakeholder category	Number	Share (%)
Third party industry suppliers	7	14%
Universities/academic bodies	5	10%
Urban passenger operators	2	4%
TOTAL	**50**	**100%**

B.4.3 Key results/messages from the targeted consultation

Effectiveness

Objectives

Stakeholders generally indicated that they agree on the Shift2Rail objectives. Most of them noted that they are broad and exhaustive. A common point raised by different stakeholders (Shift2Rail members and non-members) is that objectives are ambitious and difficult to achieve. Nevertheless, there is a consensus from the interviewed stakeholders that Shift2Rail is contributing to achievement of the objectives. Few stakeholders indicated that Shift2Rail is not yet achieving the planned results.

There is a consensus that the current objectives remain valid for the future.

Several stakeholders noted that objectives' achievement need stronger deployment efforts, and focus on users, to make rail the backbone of European transport systems. In particular, several interviewees highlighted that inter-modality and door-to-door mobility (rail-last mile integration) are key objectives for rail development, and this calls for innovations which are attractive to rail users (including their experience), to foster rail mode take-up and to make European transport systems greener (more focus needed on sustainability). Interoperability and network efficiency were also indicated as key objectives.

Specific stakeholders indicated that constraints in achieving the objectives are:

- Interoperability and ERTMS deployment levels are transversal to the Shift2Rail objectives and have the potential to open the EU-wide market to innovation.
- The long-life cycle of rail assets limits technology evolution and innovation adoption.
- Investments needed to change and innovate the rail sector (which has slower innovation processes than other sectors).

Additional objectives that stakeholders proposed to be included more prominently are:

- supporting the European rail industry competitiveness in global markets;
- accelerating innovation deployment; and
- reducing innovation time to market.

Moreover, some stakeholders (both members and not members) proposed a stronger focus on specific themes, in particular:

- urban rail transport;
- rail freight transport;

- rail service level; and
- energy consumption.

Concerning the specific questions on how a co-programmed partnership or the Horizon Europe Programme alone could achieve the future objectives, most stakeholders (especially members) indicated that the Joint Undertaking instrument allows better achievement of objectives; the main reasons they reported are:

- creating an over-reaching picture in rail research, which would not be possible with the Horizon Europe Programme alone and by single research projects (in particular in terms of coordination of the multiple rail sub-systems' research activities);
- fostering cooperation in the rail sector, in particular engaging competing businesses in R&I cooperation and in finding solutions for the rail sector needs;
- the legal certainty that the Joint Undertaking brings to members/innovation investors, as a condition for industry players to invest;
- easing technology and operational harmonisation (reducing the rail sector fragmentation) across Europe;
- accelerating the sector transformation, also to compete on global markets (e.g. Chinese competition);
- allowing longer term cooperation among research stakeholders to move to higher TRL levels; and
- being an independent party for business players.

Some stakeholders also highlighted that moving from the current Joint Undertaking cooperation instrument to a co-programme partnership (or to the Horizon Programme alone) would delay rail research, slow down innovation processes and have negative impacts on the rail industry.

Membership and openness

Most Shift2Rail members and non-members noted that Shift2Rail involves the most important rail stakeholders in Europe and that it reflects the rail business in Europe. In particular, they highlighted that the involvement of big industry players allows the financial commitment needed to transform the rail system. On the other hand, most of members and non-members indicated that:

- Research organisations, SME and smaller players (including players in the urban rail sector) faced difficulties in joining Shift2Rail, due to lack of capacity to invest (funding needed) and bureaucracy to apply, and that this explains why some stakeholders joined through networks/consortia of stakeholders.
- The current partnership has a strong focus on technology/equipment providers, and the future collaboration framework should be more open to other types of stakeholders, in particular infrastructure managers and railway operators.

Generally, members and non-members think that more flexibility is needed to engage stakeholders based on research needs' development. Several members proposed and supported the development of mega-projects in which members and non-members cooperate, and which could have flexibility in engaging partners as the projects develop (e.g. non-members delivering specific parts of the mega-projects). On the other hand, two stakeholders indicated that bigger projects increase management workload and do not necessarily deliver improved impacts.

We did not record specific issues with reference to funding for members, associated members and non-members, and stakeholders generally indicated that this reflects investments in Shift2Rail. In particular, some stakeholders noted that the funding also needs to cover prototypes and industrial projects, and this justifies that more budget needs to be available. Non-members indicated that open calls are important, especially considering low national budgets for rail research.

Some stakeholders (especially members) noted the geographical imbalance of membership, but also that this reflects the current rail industry geographic balance and the related dominant position of some Member States. They indicated that open calls can enhance more geographical balance, noting that Eastern European rail supply industry companies include smaller players and that state-owned infrastructure managers and railway undertakings face difficulties for joining a Joint Undertaking.

Several interviewees commented that the urban sector is poorly represented in the current member composition, although they noted that it may be constrained by funding from participating into a Joint Undertaking.

Specific stakeholders' proposals on types of members to include, or to include more prominently, are:

- verification and certification bodies (to ensure that innovations are usable on national rail networks and compatible with interoperability standards);
- national authorities (or at least improving the communication with them) in order to understand the technologies employed locally and to foster regulatory harmonisation;
- infrastructure managers and railway undertakings, to allow more focus on rail operational and service aspects, and to improve the balance of membership between suppliers and users of rail innovations (the latter could be involved in specification and deployment activities); and
- rail freight nodes (including ports and terminals), which are users of innovation and an important component of logistics chains.

Both members and non-members (with a prevalence of non-members) noted that Shift2Rail should be more open and flexible and that it is difficult for non-members to join through open calls. More openness would allow for a further alignment with the research needs of a wider stakeholder group. In particular, a key stakeholder indicated that there could be two or three waves of innovation (e.g. 2021-25 and 2025-30) and the identity of members may not be fixed in the Joint Undertaking Regulation (as it was not in SESAR).[54] The Regulation could specify the types of organisation to engage.

With specific reference to the involvement of universities, stakeholders generally indicated that they have an important role in supporting industrial innovation in bringing a long-term perspective to research activities.

A common point for almost all stakeholders, other than rail providers and manufacturers, was the balance between "blue sky research" and research focused on members' priorities. In particular, research stakeholders noted that business players tend to consider innovation in the shorter term, while universities look at innovation on a longer timescale (and that business players have difficulties in developing advanced research which may bring business results only in the long term). One stakeholder noted that an important element is the "migration" of innovation: blue sky research needs time to go to the market and

[54] Single European Sky ATM Research (SESAR) is a collaborative project to completely overhaul European airspace and its air traffic management (ATM). The actual programme is managed by the SESAR Joint Undertaking.

when it is ready new technologies may develop and make "blue sky research" results obsolete.

Concerning openness, several stakeholders (in particular most of the Shift2Rail members or other stakeholders engaged in Shift2Rail activities) indicated that research activities in open call projects are not aligned with the research priority of members. Generally, stakeholders noted that a closer cooperation between members and non-members is needed in the future, and that a better integration of members' and non-members research projects is needed.

Concerning calls, some stakeholders (members and non-members) noted that members should not need to apply to calls, and that this would allow more focus on content rather than process.

Concerning the partnership dimension, the main suggestion was to increase the number of core members to 15-20 and to engage additional stakeholders on a project basis and based on research needs.

Efficiency

Leverage effect

Generally, stakeholders indicated that Shift2Rail has the capacity to leverage private investments and to allow the coordination of investments in risky fields (e.g. risk-sharing facility). Several members indicated that this was possible thanks to the Join Undertaking contractual obligations, and a lighter form of cooperation instrument (e.g. co-programme partnership) would not have achieved the same results (and would even have prevented their participation). In particular, a binding agreement was indicated as a condition for public sector entities to join the cooperation instrument (or approve participation of owned companies) as the JU legal framework provides certainty and transparency.

Some stakeholders also indicated that Shift2Rail has the advantage of concentrating R&I innovation funds for the rail sector and this improves fund leverage.

A topic raised by several interviewees was the extent to which the TRL levels achieved in projects undertaken within Horizon Europe may differ from those achieved under Horizon 2020. Generally, members and non-members indicated that research projects under Horizon 2020 focus on TRL 1-3 and do not go beyond 6-7. Shift2Rail members (but also interviewed stakeholders who are innovation users) wished a push to higher TRL and more deployment and market up-take of rail innovations. They also indicated that an important component of this would be that research is accompanied by solid business cases to roll out innovation.

Key Performance Indicators (KPI)

There was a general agreement by members that KPI are difficult to measure, and their targets refer to long-term objectives which are very ambitious and influenced by factors external to Shift2Rail. Nevertheless, stakeholders indicated that KPI types are broadly appropriate for the sector; some stakeholders indicated that ambitious KPI targets are set to stimulate breakthrough change in the rail sector.

Stakeholders indicted that KPIs refer to the Shift2Rail objectives and are still valid for the future. Suggestions for KPI improvements concerned:

- defining the baseline values; in particular some stakeholders indicated this is a sensitive topic due to confidentiality of business information;
- defining KPI assumptions and framework;
- defining KPI more specifically;

- including KPI on:
  - bringing R&I results to the market;
  - rail regulatory harmonisation issues (e.g. cross-border rail services facing different standards);
  - rail freight transport;
  - rail hubs;
  - data sharing;
  - rail attractiveness to passengers, with reference to satisfaction, experience and comfort; and
  - noise and energy topics.
- including more focus on coordination with other transport modes and decarbonisation of the transport sector.

Costs and benefits

There was a general agreement that Shift2rail's cost-benefit balance is positive. Some non-members did not comment on the topic as they felt they had insufficient information to assess it. Interviewees indicated the following benefits of the Joint Undertaking cooperation instrument compared to an EU Research & Innovation programme alone or a co-programme partnership:

- more focused calls compared to FP7 and Horizon 2020 (specialisation);
- long-term vision, which is important to the European Commission and to parties committing to financial support (H2020 projects typically last 2-3 years; technology evolution is fast, and a JU is more effective in addressing changing challenges compared to short term projects);
- more visibility compared to other cooperation instruments;
- legal certainty;
- reduced fragmentation in research investments/results, avoiding duplication of effort;
- joint EU approach to solving the rail industry technical problems;
- wider scale demonstrators and higher TRL; and
- management transparency (compared to projects funded under general Horizon 2020 calls).

On the other hand, interviewees also indicated the following areas of improvement in relation to the current Joint Undertaking:

- The budget should be higher, and as a consequence many projects have low TRL; in particular, stakeholders indicated that economic return is an important element to ensure investment by industrial players and higher TRL allow reducing time to returns.
- There could be more flexibility to allocate funding to "blue sky research", and this will need balancing with industry economic needs in the shorter term.
- The multiannual work plan should be flexible and suited to changes.
- Innovation Programmes should be more connected.
- More visibility of activities/research results across IPs is needed.
- A higher level of cooperation between the EC and Members States is needed.

Critical elements raised by stakeholders concerned:

- the usability of results in the national contexts;

- confidentiality of project results, which limit their diffusion;
- limited contribution from some partners of open call projects;
- implementation of R&I outputs;
- a high degree of bureaucratisation, with complicated rules of cooperation (despite the need for transparency); nevertheless, some stakeholders noted that non-Shift2Rail European research projects also suffer administrative complexity; and
- communication and presentation of research results; in particular, several non-members indicated that they are not aware of the Shift2Rail results.

One stakeholder involved in Shift2Rail activities and projects indicated that project implementation would be better in a co-programmed partnership because member and non-member projects are insufficiently coordinated; it proposed an intermediate approach as in the FCH JU, which allows more flexibility to react on research needs and related stakeholder engagement/cooperation. In particular, it indicated that engaging non-members is very difficult, and only possible by open calls.

Equally, another stakeholder indicated that open calls would be their preferred policy option, as it would provide the greater flexibility among all options, including with regards to the research topics as well as membership composition.

Relevance

Need for a rail EU partnership

There is a general agreement that an EU partnership for rail is needed in the future. Most stakeholders suggested follow-up of Shift2Rail to complement, to continue, to deploy previous and ongoing activities and to complete the transformation of the rail sector. Stakeholders confirmed the advantages of Shift2Rail that they indicated in previous parts of the interviews, in particular:

- Shift2Rail brought more clarity than single projects and brought together research and business players.
- European support under Horizon Europe alone would not address the issue of industry fragmentation (as it would rely on *ad hoc* project consortia, which pursue specific R&I interests without proper coordination).
- In the JU all sector representatives are around the table (EC, Member States, Infrastructure Managers, rail operators, rail suppliers, etc.).
- Other types of partnerships can contribute to generating "silos" in research and isolated groups of stakeholders.
- The JU cooperation instrument is essential to public sector entities which have specific investment rules requiring a demonstration of investment returns and legal certainty.
- It brings competing companies into R&I cooperation and innovation investment risk sharing.
- The Shift2Rail brand helps selling EU rail R&I results internationally.

Several stakeholders also suggested changes and improvements to the current partnership with reference mainly to:

- openness and membership composition; and
- integration between call for members and call for non-members.

Research needs

Stakeholders proposed the following priority topics in rail research:

- digitalisation and digital transformation of the sector (including fleet management, maintenance, homologation/certifications);
- IT/augmented reality/digitalisation in signalling and remote control;
- multimodality and rail last mile integration, better connection among transport modes and development of door-to-door services, also thanks to Mobility as a Service solutions and integration of passenger facing systems (e.g. booking and ticketing);
- artificial intelligence and robotics for maintenance;
- 5G, data (including Internet of Things), data management and cybersecurity;
- rail freight terminals, including automatic coupling and single wagon development, supply chain data exchange;
- automation on mainlines and computer-based controls; Automatic Train Operations and their impacts on infrastructure;
- innovation in track materials and level of wear and tear of the rolling stock on rail infrastructure;
- decarbonisation and low carbon technologies;
- rail capacity improvement;
- new materials (e.g. carbon fibre);
- new methods of maintenance/asset management;
- noise; and
- safety and security.

One stakeholder indicated the following overarching vision of research topics for the rail industry:

- automation of systems;
- door-to-door mobility ecosystem;
- lifecycle management and asset management (whole life approach);
- green and environmental sustainability (carbon free); and
- transversal enabler (e.g. new materials, cybersecurity, digital technologies, big data).

Concerning ERRAC's role in respect to Shift2Rail, most stakeholders indicated that:

- ERRAC has the role in defining the rail sector's needs, as it involves the whole industry (including innovation users).
- It focuses on a strategic level (advisory role) as initiator of the rail vision, and has the role to provide inputs to define research topics and priorities (feeding the JU strategy).
- ERRAC is an independent player, not bound to formal memberships and call processes.
- It has a role in bringing the innovation user's perspective and new ideas to Shif2Rail.

Some stakeholders indicated that a stronger partnership between ERRAC and JU is needed. On the other hand, some indicated that the future cooperation instrument could be a light partnership (not a JU) working with ERRAC.

Coherence

Contribution to EU policies

Stakeholders confirmed the importance of Shift2Rail to EU policy objectives. Nevertheless, a common input by several stakeholders was that Shift2Rail focuses on rail research (and in particular on technology aspects), but not on implementing innovation in the market, which is needed to achieve EU policy objectives.

The topics of commercial viability of innovation, and of rail competitiveness and integration with other transport modes to address environmental policy objectives, were identified by several stakeholders as key areas for a future research partnership. Stakeholders indicated that the future partnership could focus on:

- increasing rail efficiency and attractiveness to users to achieve modal shift;
- promoting the rail sector to policy makers and in particular informing European policies by bringing the industry knowledge, technical evidence and expertise; and
- focussing more on projects delivering competitive products/service deployment and the market uptake of innovation.

Governance/organisation

Stakeholders generally agreed that Shift2Rail is well-managed and that its governance/organisation is suitable to its mission. They indicated that it is important to have a European "single window" in rail research and one body coordinating research (avoiding research duplication) and being accountable for research funds.

Concerning governance JU members identified the following main areas of improvement:

- The Governing Board should have more focus on strategic topics and less on procedural issues and financial management.
- The Governing Board is very broad, and the number of members could be reduced.
- The Scientific Committee could be more involved and have more influence, also involving representatives of the industry.

Concerning organisation, different non-members highlighted that a stronger national presence is needed (either in terms of communication or contact points) and that this would allow promoting and marketing research results. Better coordination with Member States was also suggested.

Some stakeholders also suggested a more open and flexible governance (or cooperation instrument) which may also focus on types of projects and have a wider stakeholder involvement in decision-making. In particular, they indicated that shorter-term projects (e.g. facing emerging innovation needs or targeted to innovation take-up) may be better activated by a lighter type of partnership also involving innovation users.

Further suggestions concerned developing project financing, which includes rail innovation in infrastructure investments.

Some members indicated that administrative processes and reporting are very complex, that the lead time from calls to project start is long, and that there are several calls, which generates fragmentation.

Concerning the Innovation Programme structure, stakeholders indicated that it could be improved and that it brings some fragmentation in research activities.

Several of the interviewed stakeholders indicated that Shift2Rail should look more for non-rail industry innovation (e.g. one proposal concerned S2R groups focused on "scouting" technologies from other sectors) and cooperate more with other partnerships to leverage technologies developed outside the rail industry (also thanks to the cooperation among EC General Directions).

EU added-value

All the stakeholders called for EU action in rail research and innovation. They indicated that a key EU role is reducing fragmentation of the rail system, in both the technical component of research activities and institutional and political cooperation. In particular, they indicated that EU action can extend beyond pure technical issues.

Moreover, some stakeholders indicated that JU is an instrument to support the EU rail industry's competitiveness at global level.

Further benefits of the EU actions that stakeholders indicated were:

- making funds available, especially considering the poor funding for rail research in some Member States;
- tackling topics (e.g. interoperability, ERTMS) which have an EU dimension and cannot only be tackled at national level;
- sustaining rail as the greenest transport mode and helping rail to innovate;
- coordinating rail research to avoid research developing in parallel by single stakeholders or groups of stakeholders (e.g. EU as a catalyst to efficiently deliver rail research), and
- bringing together competitors in rail innovation (especially in a fragmented sector like rail).

B.5 Open public consultation on the Candidate institutionalised European Partnerships

B.5.1 Approach to the open public consultation

The consultation was open to everyone via the EU Survey online system.[55] The survey contained two main parts and an introductory identification section. The two main parts collected responses on general issues related to European partnerships (in Part 1) and specific responses related to 1 or more of the 12 candidate initiatives (as selected by a participant).

The survey contained open and closed questions. Closed questions were either multiple choice questions or matrix questions that offered a single choice per line, on a Likert-scale. Open questions were asked to clarify individual choices.

The survey was open from 11 September till 12 November 2019. The consultation was available in English, German and French. It was advertised widely through the European Commission's online channels as well as via various stakeholder organisations.

The analysis of the responses was conducted by applying descriptive statistic methods to the answers of the closed questions and text analysis techniques to the analysis of the answers of the open questions. The keyword diagrams in this report have been created by

[55] https://ec.europa.eu/eusurvey/runner/ConsultationPartnershipsHorizonEurope

applying the following methodology: First, the open answer questions were translated into English. This was followed by cleaning of answers that did not contain relevant information, such as "NA", "None", "no comment", "not applicable", "nothing specific", "cannot think of any", etc. In a third step, common misspellings were corrected, such as "excellence" instead of "excellence", or "partnership" instead of "partnership". Then, then raw open answers were tokenised (i.e. split into words), tagged into parts of speech (i.e. categorised as a noun, adjective, preposition, etc) and lemmatised (i.e. extraction of the root of each word) with a pre-trained annotation model in the English language. At this point, the second phase of manual data cleaning and correction of the automatic categorisation of words into parts of speech was performed. Finally, the frequency of appearance and co-occurrences of words and phrases were computed across the dataset and the different sub-sets (e.g. partnerships, stakeholder groups). Data visualisations were created based on that output.

The keyword graphs in the following sections have been built based on the relationships between words in the open responses of the survey participants. It features words that appear in the same answer either one after the other or with a maximum distance of two words between them. Each keyword is represented as a node and each co-occurrence of a pair of words is represented as a link. The size of the nodes and the thickness of the links vary according to the number of times that keywords are mentioned and their co-occurrence, respectively. In order to facilitate the visualisation of the network, the keyword graphs have been filtered to show the 50 most common co-occurrences. Although the keywords do not aim to substitute a qualitative analysis, they assist the identification of the most important topics covered in the answers and their most important connections with other topics, for later inspection in the set of raw qualitative answers.

B.5.2 Overview of respondents to the open public consultation

Profile of respondents

In total, 1635 respondents filled in the questionnaire of the open public consultation. Among them, 272 respondents (16.64%) were identified to have responded to the consultation as part of a campaign (coordinated responses). Based on the Better Regulation Guidelines, the groups of respondents where at least 10 respondents provided coordinated answers were labelled as *'campaigns',* segregated and analysed separately and from other responses. In total 11 campaigns were identified. In addition, 162 respondents in the consultation also display similarities in responses but in groups smaller than 10 respondents. Hence, these respondents were not labelled as campaigns and therefore were not analysed separately from the general analysis.

Among the 1635 respondents, 1178 (72.05%) completed the online consultation in English, 141 (8.62%) in German, 89 (5.44%) in French, 58 (3.55%) in Italian and 47 (2.87%) in Spanish, see Figure 12. Respondents that belong to the 11 campaigns follow the same pattern of language distribution, with English being the dominant language of respondents in that group. Table 26 shows that over 50% of respondents come from 4 Western and Southern European countries – Germany, Italy, France and Spain. Overall, the number of respondents from Eastern and Northern Europe is lower, while among non-EU countries the greater number of respondents come from Switzerland, Norway and Turkey, which are countries associated to the Framework Programme. In the group of respondents labelled as campaigns, most respondents are from Germany (48 respondents or 17.65%), France (39 respondents or 14.34%), Italy (37 respondents or 13.6%), Belgium (23 respondents or 8.46%), the Netherlands (21 respondents or 7.72%) and Spain (17 respondents or 6.25%). Hence, a similar pattern of country of origin is observed in the entire sample of respondents and for the campaigns.

Across all respondents 40.80% indicated to answer to the open public consultation in a public way (non-anonymous) and 20.67% of all respondents indicated their Transparency Register number.

Figure 12: Language of the consultation that selected respondents (N=1635) (non-campaign replies) Aggregation of responses of all candidate initiatives

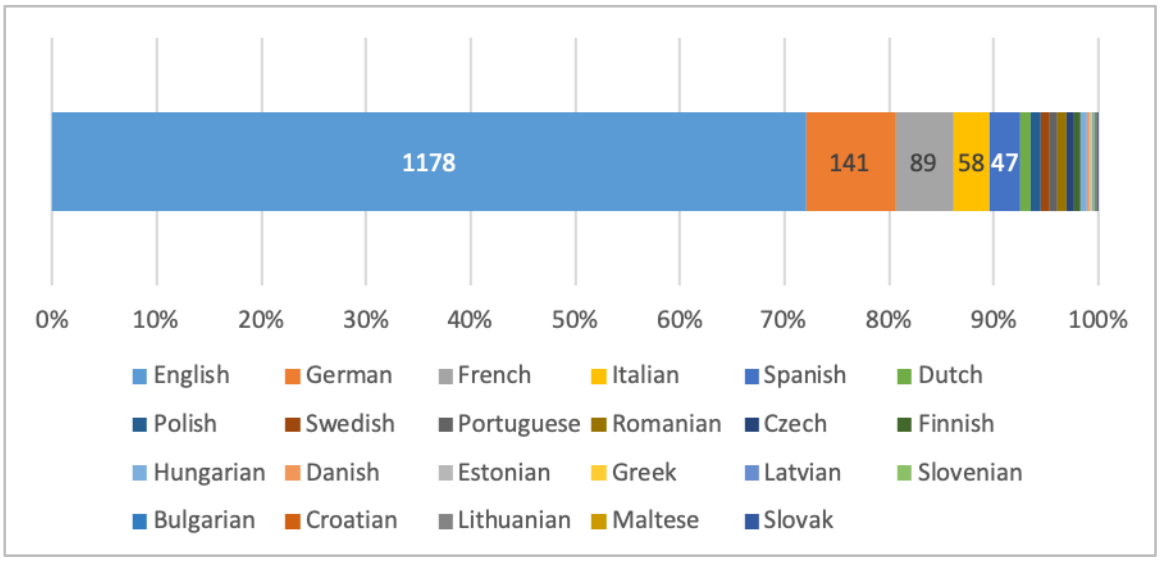


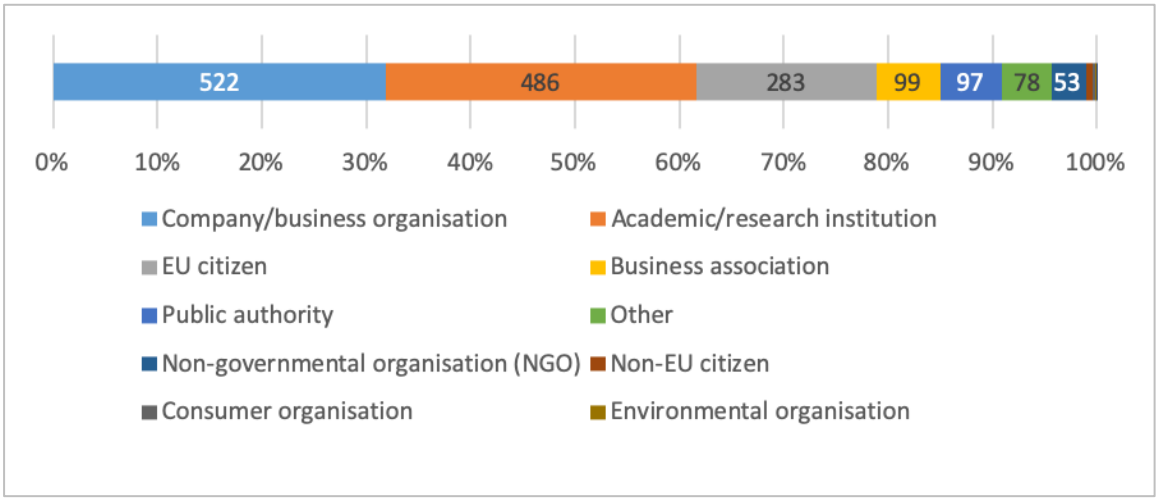
Table 26: Country of origin of respondents (N=1635)

Country	Number of respondents	Percentage of respondents
Germany	254	15.54%
Italy	221	13.52%
France	175	10.70%
Spain	173	10.58%
Belgium	140	8.56%
The Netherlands	86	5.26%
Austria; United Kingdom	61	3.73%
Finland	49	3.00%
Sweden	48	2.94%
Poland	45	2.75%
Portugal	32	1.96%
Switzerland	28	1.71%
Czechia	24	1.47%
Greece	23	1.41%
Norway; Romania	22	1.35%
Denmark	20	1.22%
Turkey	19	1.16%
Hungary	14	0.86%

Country	Number of respondents	Percentage of respondents
Ireland	12	0.73%
United States	11	0.67%
Estonia; Slovakia; Slovenia	10	0.61%
Bulgaria; Latvia	9	0.55%
Bosnia and Herzegovina	7	0.43%
Lithuania	4	0.24%
Canada; Croatia; Israel	3	0.18%
China; Ghana; Iceland; Japan; Luxembourg; Morocco	2	0.12%
Bhutan; Botswana; Cyprus; Iran; Malta; Mexico; Moldova; Mongolia; Palestine; Russia; Serbia; South Africa; Tunisia; Ukraine; Uruguay	1	0.06%

According to Figure 13, the three biggest groups of respondents are companies and business organisations (522 respondents or 31.93%), academic and research institutions (486 respondents or 29.72%) and EU citizens (283 respondents or 17.31%). Business associations, representing multiple businesses, were the fourth largest responding group (99 respondents or 6.05%), no other types of associations were presented amongst the selectable options for respondents. Among the group of respondents that are part of campaigns, most respondents are provided by the same groups of stakeholders, namely companies and business organisations (121 respondents or 44.49%), academic and research institutions (54 respondents or 19.85%) and EU citizens (42 respondents or 15.44%).

Figure 13: Type of respondents (N=1635) (non-campaign replies) Aggregation of responses of all candidate initiatives



Respondents were asked to indicate the organisational size of the companies, organisations and institutions they work for. Based on Table 27, a greater number of respondents work in large companies and business organisations (295 respondents out of 522 or 56.51%) and large academic and research institutions (348 respondents out of 486 or 71.60%). A greater number of respondents that are employed by business associations and NGOs indicated an organisation size of 1 to 9 employees. Among the group of respondents that are marked as campaigns, a greater number of respondents work in large companies and business organisations (82 respondents out of 121 or 67.77%) and academic and research institutions (39 out of 54 respondents or 72.22%).

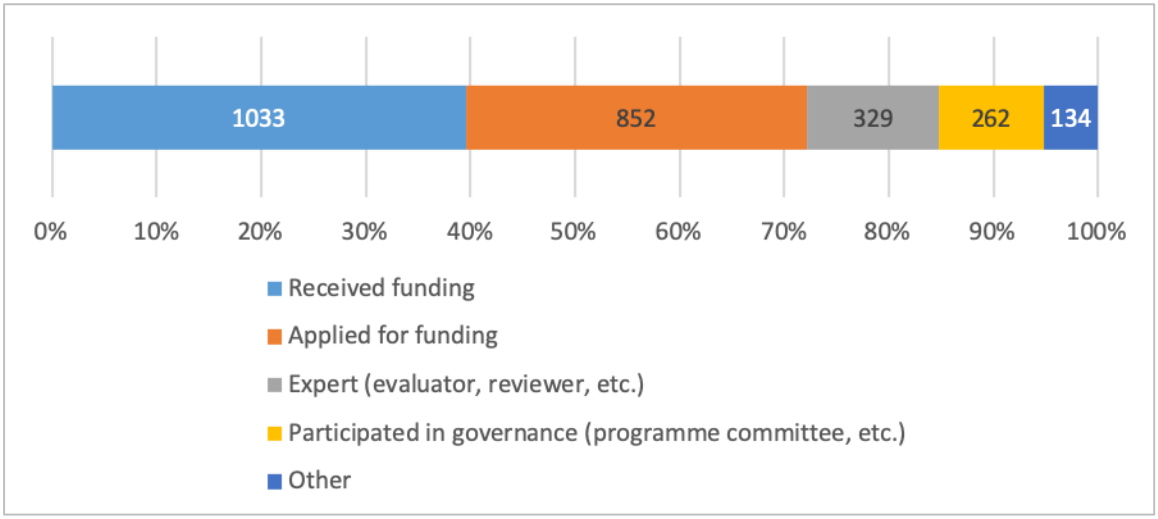
Table 27: Size of organisations that represent consultation respondents (N=1635)

	Organisation size			
Type of respondents' organisations	**Large (250 employees or more)**	**Medium (50 to 249 employees)**	**Small (10 to 49 employees)**	**Micro (1 to 9 employees)**
Company/business organisation	295	66	90	71
Academic/research institution	348	95	31	12
Business association	15	6	34	44
Public authority	58	33	6	0
Non-governmental organisation (NGO)	7	9	11	26
Consumer organisation	1	0	2	1
Environmental organisation	0	0	1	0
Trade union	0	0	1	0
Other	24	16	19	19

Among all consultation respondents, 1303 (79.69%) have been involved in the on-going research and innovation framework programme Horizon 2020 or the preceding Framework Programme 7, while 332 respondents (20.31%) were not. In the group of campaign respondents, the share of those who were involved in these programmes is higher (245 respondents out of 272 or 90.07%) than in the group of non-campaign respondents (1058 out of 1363 or 77.62%). When respondents that participated in the Horizon2020 or in the preceding Framework Programme 7 were asked to indicate in which capacity they were involved in these programmes, the majority stated that they were a beneficiary (1033 respondents or 39.58%) or applicant (852 respondents or 32.64%).

The main stakeholder categories, e.g. companies/business organisation, academic/research institutions, etc., show a similar distribution across the capacities in which they 'have been involved in Horizon 2020 or in the Framework Programme 7' as the overall population of consultation respondents (see distribution in Figure 14). However, a few stakeholder categories have mainly been involved in the capacity of "Received funding" and/or "Applied for funding", this applies to business associations, NGOs and public authorities.

Figure 14: Capacity in which respondents were involved in Horizon 2020 or in the Framework Programme 7 (N=1303)(non-campaign replies) Aggregation of responses of all candidate initiatives, multiple options allowed



Among those who have been involved in the on-going research and innovation framework programme Horizon 2020 or the preceding Framework Programme 7, 1035 respondents (79.43%) are/were involved in a partnership. The share of respondents from campaigns that are/were involved in a partnership is higher than for non-campaign respondents, 89.80% versus 77.03% respectively. The list of partnerships under Horizon 2020 or its predecessor Framework Programme 7 together with the numbers, percentages of participants is presented in Table 28, the table also shows the key stakeholder categories for each partnership.

Most consultation respondents participated in the following partnerships: Fuel Cells and Hydrogen 2 (FCH2) Joint Undertaking, Clean Sky 2 Joint Undertaking, European Metrology Programme for Innovation and Research (EMPIR) and in Bio-Based Industries Joint Undertaking. The comparison between the non-campaign and campaign groups of respondents shows that the overall distribution is quite similar. However, there are some differences. For the campaign group almost a half of respondents is/was involved in the Fuel Cells and Hydrogen 2 (FCH2) Joint Undertaking, a higher share of campaign respondents is/was participating in Clean Sky 2 Joint Undertaking and in Single European Sky Air Traffic Management Research (SESAR) Joint Undertaking.

Table 28: Partnerships in which consultation respondents participated (N=1035)

Name of the partnership	Number and % of respondents from both groups (n=1035)	Number and % of respondents from a non-campaign group (n=815)	Academic/research institutions	Business associations	Company/business organisations	Company/business organisations	EU citizens	NGOs	Public authority
Fuel Cells and Hydrogen 2 (FCH2) Joint Undertaking	354 (33.33%)	247 (30.31%)	97	9	37	43	41	8	5
Clean Sky 2 Joint Undertaking	195 (18.84%)	145 (17.79%)	57	2	10	27	37	1	7
European Metrology Programme for	150 (14.49%)	124 (15.21%)	64	0	13	9	14	2	19

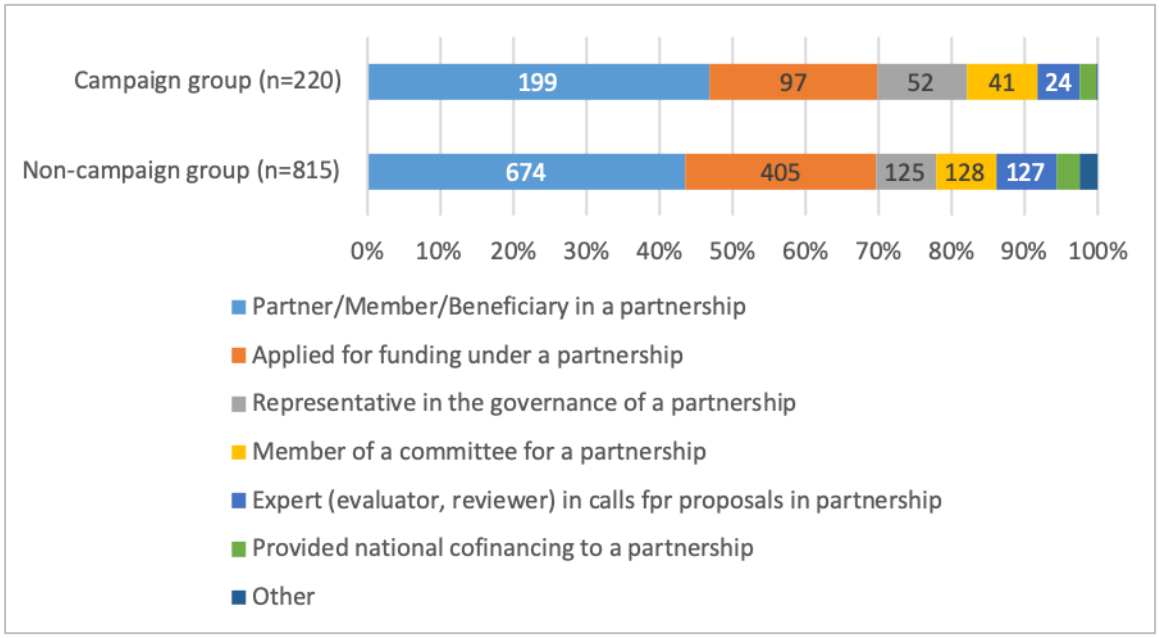
Name of the partnership	Number and % of respondents from both groups (n=1035)	Number and % of respondents from a non-campaign group (n=815)	Academic/research institutions	Business associations	Company/business organisations	Company/business organisations	EU citizens	NGOs	Public authority
Innovation and Research (EMPIR)									
Bio-Based Industries Joint Undertaking	142 (13.72%)	122 (14.97%)	39	8	20	27	14	1	6
Shift2Rail Joint Undertaking	124 (11.98%)	101 (12.40%)	31	7	5	31	14	3	7
Electronic Components and Systems for European Leadership (ECSEL) Joint Undertaking	111 (10.72%)	88 (10.80%)	42	2	7	20	12	0	5
Single European Sky Air Traffic Management Research (SESAR) Joint Undertaking	66 (6.38%)	46 (5.64%)	10	3	3	20	3	2	3
5G (5G PPP)	53 (5.12%)	47 (5.77%)	20	1	6	14	5	0	1
Eurostrars-2 (supporting research-performing small and medium-sized enterprises)	44 (4.25%)	40 (4.91%)	17	0	6	1	7	0	6
Innovative Medicines Initiative 2 (IMI2) Joint Undertaking	37 (3.57%)	35 (4.29%)	18	2	3	3	2	4	3
Partnership for Research and Innovation in the Mediterranean Area (PRIMA)	28 (2.71%)	26 (3.19%)	15	0	3	1	2	0	2
European and Developing Countries	25 (2.42%)	24 (2.94%)	12	0	1	2	3	3	2

Name of the partnership	Number and % of respondents from both groups (n=1035)	Number and % of respondents from a non-campaign group (n=815)	Academic/research institutions	Business associations	Company/business organisations	Company/business organisations	EU citizens	NGOs	Public authority
Clinical Trials Partnership									
Ambient Assisted Living (AAL 2)	22 (2.13%)	21 (2.58%)	11	2	1	1	3	0	3
European High-Performance Computing Joint Undertaking (EuroHPC)	22 (2.13%)	18 (2.21%)	6	0	2	3	5	0	2

When respondents were asked in which role(s) they participate(d) in a partnership(s), over 40% indicated that they act(ed) as partner/member/beneficiary in a partnership (see Figure 15). The second largest group of respondents stated that they applied for funding under a partnership. The roles selected by non-campaign and campaign respondents are similar.

The few respondents that selected "Other" as their role were provided with the opportunity to outline their role. A total of 25 people did provided description. The answers provided were very varied and could not be clustered in sub-groups, a few examples are: former communication and stakeholder relationship officer, chair of steering board, system engineer, grant manager, Joint Programming Initiative (JPI), or a role in advocacy of the partnership.

Figure 15: Role of respondents in a partnership (N=1035) (non-campaign replies) Aggregation of responses of all candidate initiatives



In the open public consultation respondents could provide their views on each of the candidate Institutionalised European Partnerships, and each respondent could select multiple partnerships to provide their views on. The table below presents the number and percentage of respondents for each partnership. It is visible that the majority of respondents (31.37%) provided their views on the Clean Hydrogen candidate partnership. More than 45% of respondents from the campaigns selected this partnership. Around 15% of all respondents provided their views for the candidate partnerships European Metrology, Clean Aviation and Circular bio-based Europe. The share of respondents in the campaign group that chose to provide views on the Clean Aviation candidate partnership is of 20%. The smallest number of respondents provided opinions on the candidate initiative 'EU-Africa research partnership on health security to tackle infectious diseases – Global Health'.

Table 29: Future partnerships for which consultation respondents provide responses (N=1613)

Name of the candidate Institutionalised European partnership	Number and % of respondents from both groups (n=1613)	Number and % of respondents from a non-campaign group (n=1341)	Academic/research institutions	Business associations	Company/business organisations	Company/business organisations	EU citizens	NGOs	Public authority
Clean Hydrogen	506 (31.37%)	382 (28.49%)	123	21		55	74	8	13
European Metrology	265 (16.43%)	225 (16.78%)	112	3	21	11	34	3	28
Clean Aviation	246 (15.25%)	191 (14.24%)	57	5	21	34	54	3	8
Circular bio-based Europe: sustainable Innovation for new local value from waste and biomass	242 (15%)	215 (16.03%)	63	19	36	35	31	7	13
Transforming Europe's rail system	184 (11.41%)	151 (11.26%)	29	14	23	39	31	2	7
Key Digital Technologies	182 (11.28%)	162 (12.08%)	55	13	20	22	35	5	7
Innovative SMEs	111 (6.88%)	110 (8.20%)	19	12	39	4	14	4	10
Innovative Health Initiative	110 (6.82%)	108 (8.05%)	35	6	9	12	16	16	5
Smart Networks and Services	109 (6.76%)	107 (7.98%)	34	9	12	17	21	2	6
Safe and Automated Road Transport	108 (6.70%)	102 (7.61%)	25	12	11	19	10	3	9
Integrated Air Traffic Management	93 (5.77%)	66 (4.92%)	8	7	4	24	9	2	7
EU-Africa research partnership on health security to tackle infectious diseases – Global Health	49 (3.04%)	47 (3.50%)	15	2	4	3	12	6	4

Campaigns per candidate Institutionalised European Partnership

As was mentioned above, 11 campaigns were identified, the largest of them includes 57 respondents. The table below presents the campaigns that replied for each candidate partnership. As presented, the candidate Institutionalised Partnership Clean Hydrogen has the highest number of campaigns, namely 5. A few partnerships, such as Innovative SMEs, Smart Networks and Systems, were not targeted by campaigns. Some campaign respondents decided to provide opinions about several partnerships, therefore, campaign #2 and #6 feature in several partnerships.

Table 30: Overview of campaigns across partnerships

Name of the candidate Institutionalised European partnership	Number of a campaign group (total number of respondents in a campaign)	Number of respondents that provided views about a partnership
Clean Hydrogen	Campaign #1 (57 respondents)	57 respondents
	Campaign #2 (41 respondents)	25 respondents
	Campaign #7 (18 respondents)	18 respondents
	Campaign #9 (14 respondents)	13 respondents
	Campaign #11 (10 respondents)	9 respondents
Clean Aviation	Campaign #2 (41 respondents)	17 respondents
	Campaign #6 (19 respondents)	19 respondents
	Campaign #8 (14 respondents)	13 respondents
Integrated Air Traffic Management	Campaign #2 (41 respondents)	10 respondents
	Campaign #6 (19 respondents)	12 respondents
European Metrology	Campaign #3 (36 respondents)	35 respondents
Circular bio-based Europe: sustainable Innovation for new local value from waste and biomass	Campaign #5 (20 respondents)	20 respondents
Transforming Europe's rail system	Campaign #4 (31 respondents)	29 respondents
Key Digital Technologies	Campaign #10 (12 respondents)	12 respondents
Innovative SMEs	-	-
Innovative Health Initiative	-	-
Smart Networks and Services	-	-
Safe and Automated Road Transport	-	-
EU-Africa research partnership on health security to tackle infectious diseases – Global Health	-	-

B.5.3 Responses to the open public consultation at programme level

Characteristics of future candidate European Partnerships

Respondents were asked to assess what areas, objectives, aspects need to be in the focus of the future European Partnerships under Horizon Europe and to what extent. According to Figure 16, a great number of respondents consider that a significant contribution by the future European Partnerships is 'fully needed' to achieve climate-related goals, to the development and effective deployment of technology and to EU global competitiveness in specific sectors/domains. Overall, respondents' views reflect that many aspects require attention of the Partnerships. The least attention should be paid to responding towards priorities of national, regional R&D strategies, including smart specialisation strategies, according to respondents.

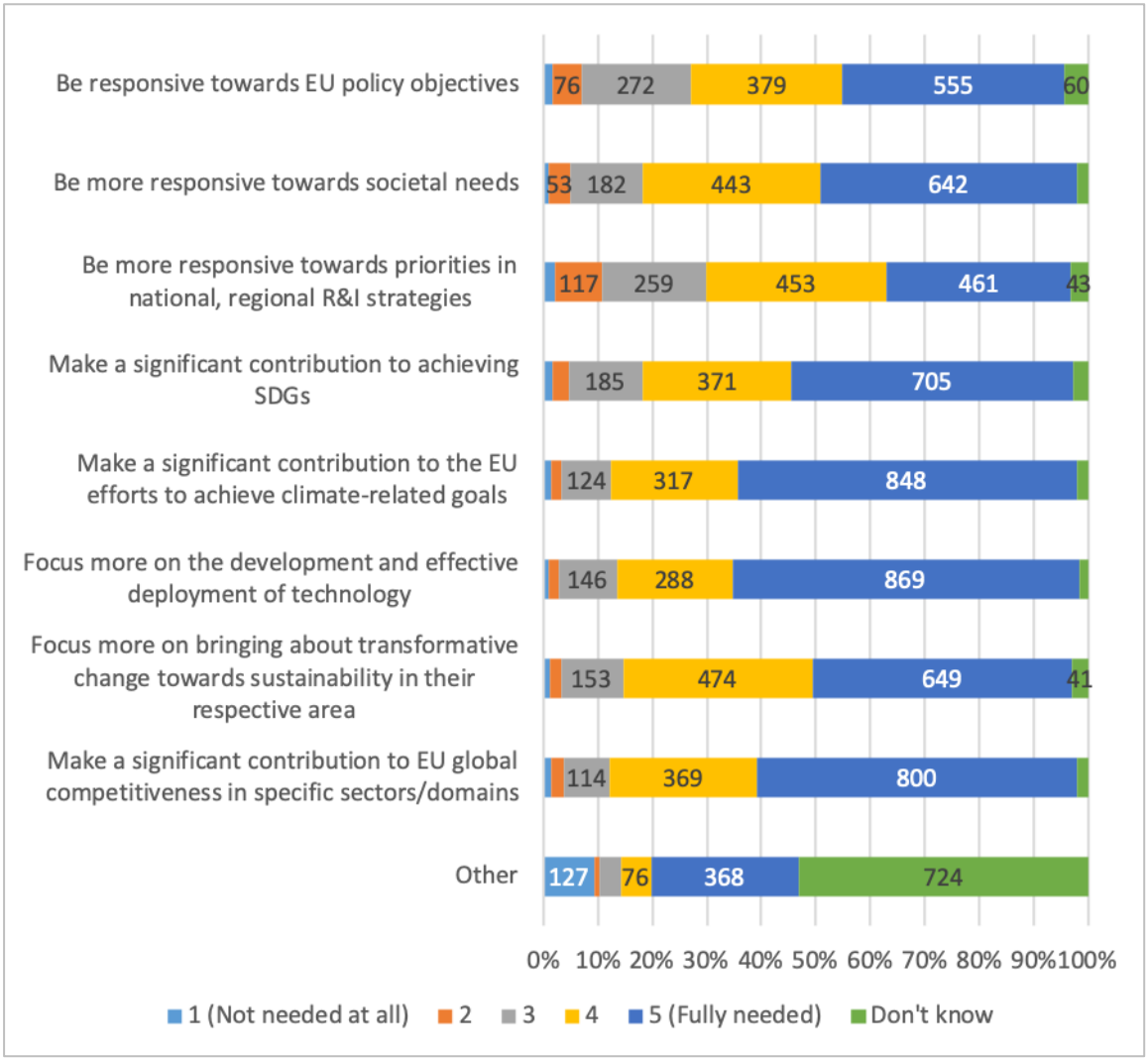
Overall, only minor differences can be found between the main stakeholder categories. Academic/research institutions value the responsiveness towards EU policy objectives and focus on development and effective deployment of technology a little less than other respondents. Business associations, however, find that the future European Partnerships under Horizon Europe should focus a little bit more on the development and effective deployment of technology than other respondents. Furthermore, business associations, large companies as well as SMEs (companies with less than 250 employees) value role of the future European Partnerships for significant contributions to EU global competitiveness in specific sectors domains a little higher than other respondents. Finally, both NGOs and Public authorities put a little more emphasis on the role of the future European Partnerships for significant contributions to achieving the UN SDGs.

The views of citizens (249, or 18.27%), both EU and non-EU citizens, that participated in the open public consultation do not reflect significant differences with other types of respondents. However, respondents that are/were directly involved in a partnership under Horizon 2020 or its predecessor Framework Programme 7 assign a higher importance of the future European Partnerships to be more responsive towards EU policy objectives and to make a significant contribution to achieving the UN's Sustainable Development Goals.

Among 272 respondents that are classified as **campaigns,** the majority (86.76%) indicated that the future European Partnerships should focus more on the development and effective deployment of technology. Other categories of presented needs that received a high score among many campaign respondents are the need to make a significant contribution to the EU efforts to achieve climate-related goals, Sustainable Development Goals and to EU global competitiveness in specific sectors/domains. The least number of campaign respondents valued the need to be more responsive towards priorities in national, regional R&I strategies (54 respondents gave a score "5 Fully needed", or 19.85%) and to be more responsive towards societal needs (71 respondents gave a score "5 Fully needed", or 26.10%).

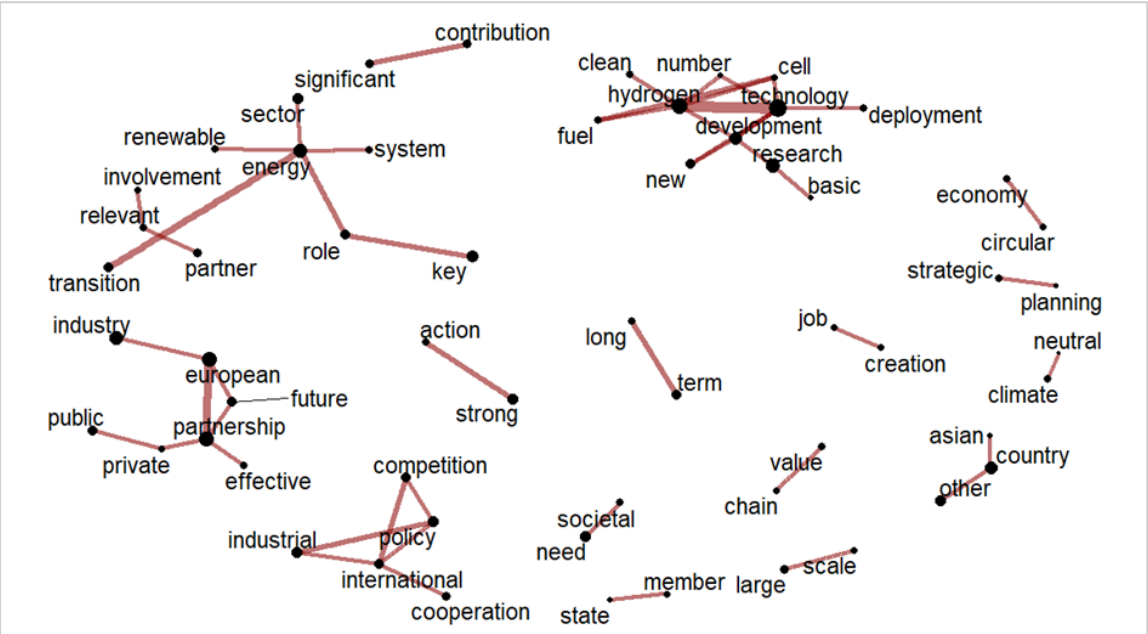
Similarly as for non-campaign respondents, we find only minor differences between the main stakeholder categories amongst campaign respondents. Academic/research institutions indicated that the future European Partnerships need to focus a little less on development and effective deployment of technology than other respondents. On the contrary, large companies find the focus on the development and effective deployment of technology a little more needed than other respondents, as do public authorities. Furthermore, large companies feel responsiveness towards priorities in national, regional R&I strategies is a little less needed than other respondents. Public authorities, however, value the responsiveness towards societal needs and priorities in national, regional R&I strategies more than others.

Figure 16: To what extent do you think that the future European Partnerships under Horizon Europe need to (N=1363) (non-campaign replies) Aggregation of responses of all candidate initiatives



The analysis of the open answers provided to explain the "Other" field show that many respondents included the set-up of public-private European partnerships and the link between industrial policy and international competition and cooperation (see Figure 17). This is confirmed through qualitative analysis of answers, many of which mention the importance of collaboration and integration of relevant stakeholders to tackle main societal challenges and to contribute to policy goals. Against this backdrop, fragmentation of funding and research efforts across Europe should be avoided. Additionally, several respondents suggested that faster development and testing of technologies, acceleration of industrial innovation projects, science transfer and market uptake are deemed as priorities. Next to that, many respondents provided answers related to the fields of hydrogen and the energy transition, which corresponds to the high number of respondents that provided answers to the candidate European Partnership specific questions related to these topics.

Figure 17: Assessment of needs, open answers to "Other" field, 50 most common co-occurring keywords (N=734) (non-campaign replies) Aggregation of responses of all candidate initiatives



Many of the respondents that are classified as campaigns took the opportunity of the "Other" field to underline their key messages. The main aspects mentioned were:

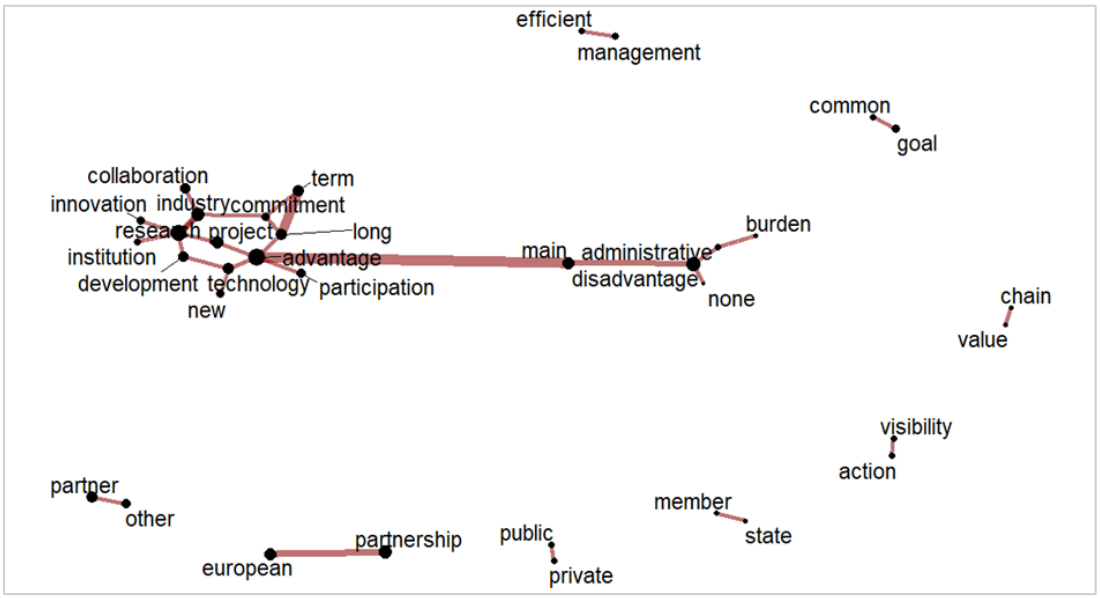
- The global positioning of Europe: outlining the role of global competition (including the role of technology), the importance of autonomy for Europe and the ability of Europe to act as a key player at the global level.
- The balance between policy objectives and private sector interests: Partnerships are regarded as an instrument to secure industry commitments due to the stability required for investments that serve policy goals.
- The importance of the transition between research and innovation (implementing research results in the market).
- The importance of multidisciplinary, and specifically cross-sectoral/cross-partnership collaboration.
- The importance of the long term commitment of a wide range of relevant stakeholders.

Next to that many respondents as part of campaigns stressed the importance of the energy transition, hydrogen and the environment, which corresponds to the high number of respondents that provided answers to the candidate European Partnership specific questions related to these topics.

Main advantages and disadvantages of Institutionalised European Partnerships

In the next question, respondents were asked to outline the main advantages and disadvantages of participation in an Institutionalised European Partnership (as a partner) under Horizon Europe. This was an open question for which a keyword analysis was used (see the main results in Figure 18). As can be observed, the advantages mentioned focus on the development of technology, overall collaboration between industry and research institutions, and the long-term commitment. Disadvantages mentioned are mainly administrative burdens.

Figure 18: What would you see as main advantages and disadvantages of participation in an Institutionalised European Partnership (as a partner) under Horizon Europe? (non-campaign replies) Aggregation of responses of all candidate initiatives, 30 most common co-occurring keywords (N=1551)



When asked about the main advantages and disadvantages of participation in an Institutionalised European Partnership (as a partner) under Horizon Europe, the following points were mentioned by respondents that are classified as campaigns:

Advantages:

- Long term commitment, stability, and visibility in financial, legal, and strategic terms
- Participation of wide range of relevant stakeholders in an ecosystem (large/small business, academics, researchers, experts, etc.)
- Complementarity with other (policy) initiatives at all levels EU, national, regional
- Efficient and effective coordination and management
- High leverage of (public) funds
- Some innovative field require high levels of international coordination/standardisation (at EU/global level)
- Ability to scale up technology (in terms of TRL) through collaboration
- Networking between members
- Direct communication with EU and national authorities

Disadvantages:

- Slow processes
- System complexity
- Continuous openness to new players should be better supported as new participants often bring in new ideas/technologies that are important for innovation
- Lower funding percentage compared to regular Horizon Europe projects
- Cash contributions
- Administrative burdens

- Potential for IPR constraints

Relevance of EU level efforts to address problems in selected areas of Partnerships

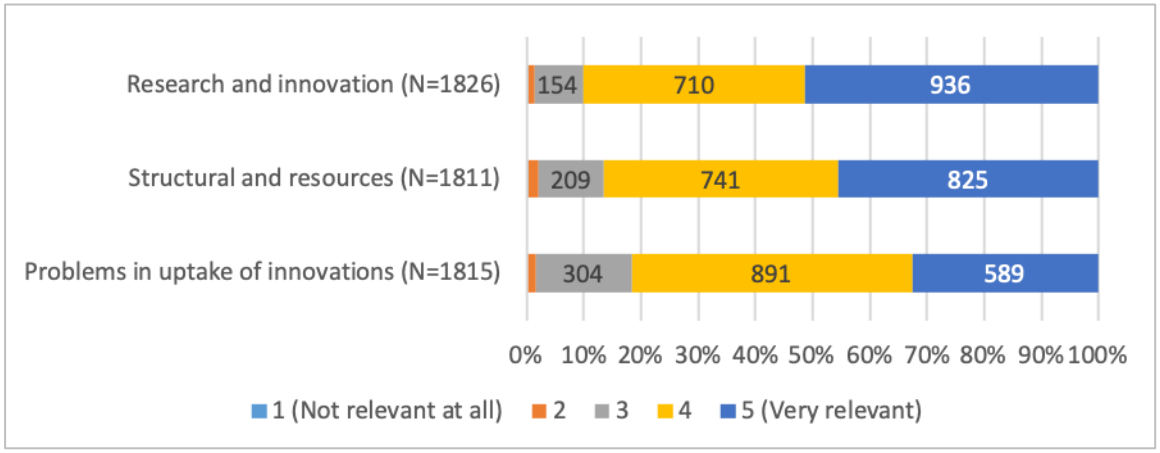
Per candidate European Partnership respondents were asked to rate the relevance of partnership specific problems in three main areas: Research and innovation problems, Structural and resource problems and Problems in the uptake of innovations. To aggregate results the average of the responses on partnership specific problems were calculated.

As presented in Figure 19, research and innovation related problems were rated as most relevant by the respondents across all candidate initiatives, followed by structural and resources problems and problems in the uptake of innovations. Overall, all three areas were deemed (very) relevant across the partnerships, as more than 80% of respondents found these challenges (very) relevant.

Only minor differences were found between the main stakeholder categories of respondents. Research and innovation problems were found slightly more relevant by academic/research institutions, yet slight less relevant by large companies and SMEs. Structural and resource problems were indicated as slightly more relevant by NGOs, but slightly less by academic/research institutions. While both NGOs and public authorities find it slightly more relevant to address problems in uptake of innovation than other respondents.

The views of citizens, both EU and non-EU citizens, are the same as other respondents (no significant differences). Respondents that are/were directly involved in a current/preceding partnership (Horizon 2020 or Framework Programme 7) find, however, the uptake of innovation problems slightly more relevant than other respondents.

Figure 19: To what extent do you think this is relevant for research and innovation efforts at EU level to address the following problems in relation to the candidate partnership in question? (non-campaign replies) Aggregation of responses of all candidate initiatives

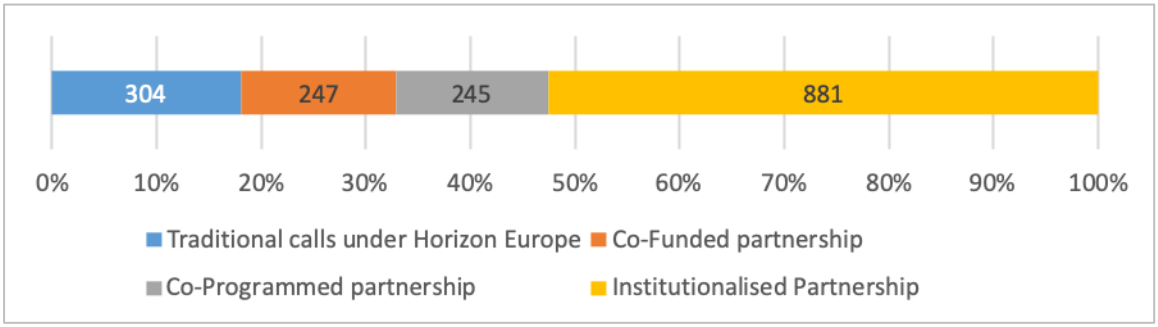


Horizon Europe mode of intervention to address problems

After providing their views on the relevance of problems, respondents were asked to indicate how these challenges could be addressed through Horizon Europe intervention. As shown in Figure 20, just over 50% of all respondents indicated that institutionalised partnerships were the best fitting intervention, however, relatively strong differences between stakeholder categories were found. The intervention of institutionalised partnerships was indicated more by business associations and large companies, but less by academic/research institutions and SMEs. While academic/research institutions valued traditional calls more often, this was not the case for business associations, large companies and public authorities. Public authorities indicated a co-programmed intervention more often than other respondents. Citizens, compared to other respondents,

indicated slightly less often that institutionalised partnerships were the best fitting intervention. Respondents that are/were directly involved in a current/preceding partnership, however, selected the institutionalised partnership intervention in far higher numbers (nearly 70%).

Figure 20: In your view, how should the specific challenges described above be addressed through Horizon Europe intervention? (non-campaign replies) Aggregation of responses of all candidate initiatives



When asked to reflect on their answers, respondents that pointed to the need for using the "institutionalised partnership" intervention mentioned the long-term commitment of collaboration, a common and ambitious R&I strategy as well as the overall collaboration between industry and research institutions. Respondents that referred to possible approaches, sometimes gave examples of good experiences in with other interventions:

1. Traditional calls because of their flexibility and integration of a wide range of actors, as long as the evaluation panels do not deviate from the policy premier. This was mentioned by 94 participants, evenly distributed across companies (25 of them), academics (26) and EU citizens (25).
2. Co-funded partnership, as a mechanism to ensure that all participants take the effort seriously, while allowing business partnerships to develop. This approach was deemed suitable based on previous experiences with ERANETs. This was raised by 84 participants, 36 of them academic respondents, 18 companies and 16 EU citizens.
3. Co-programmed partnerships to tackle the need to promote and engage more intensively with the private sector. This was mentioned by 97 participants, most of them companies (34), followed by academics (22), business associations (15) and EU citizens (11).

Relevance of a set of elements and activities to ensure that the proposed European Partnership would meet its objectives

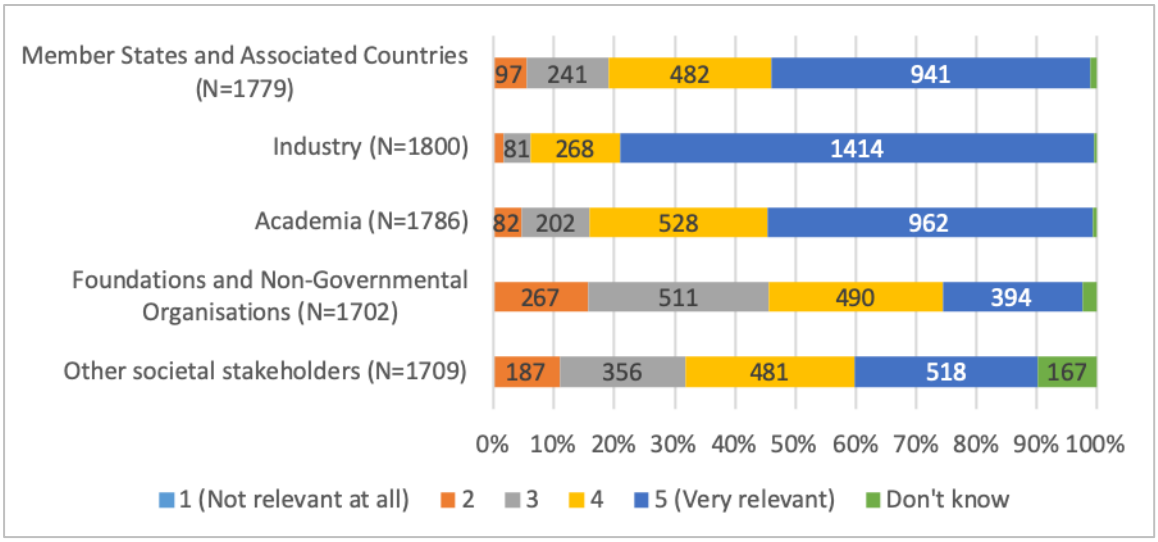
Setting joint long-term agendas

Respondents were asked how relevant it is for the proposed European Partnerships to meet their objectives to have a strong involvement of specific stakeholder groups in setting joint long-term agenda. As presented in Figure 21, collectively all respondents see stakeholders from industry as the most relevant, followed by academia and governments (Member States and Associated Countries). The involvement of foundations and NGOs as well as other societal stakeholders were, however, still found to be (very) relevant by more than 50% of the respondents.

When looking at the differences between the answers of the main stakeholder categories only minor differences could be found. Overall, it could be observed that most respondents indicated the stakeholder group they belong to themselves or that represent them as relevant to involve. Academic/research institutions find it more relevant to involve academia and less relevant to involve industry when compared to other respondents. The other way around large companies, SMEs and business associations find it more relevant

to involve industry and less relevant to involve academia, Member States and Associated Countries and NGOs. The involvement of Member States and Associated Countries was found more relevant by academic/research institutions and public authorities. NGOs also values their own involvement and those of other societal stakeholders more than other respondents. views of citizens also show a slightly higher relevance for foundations and NGOs. This is less so the case for respondents that are/were directly involved in a current/preceding partnership (most predominantly companies and academia).

Figure 21: In your view, how relevant are the following elements and activities to ensure that the proposed European Partnership would meet its objectives - Setting joint long-term agenda with strong involvement of: (non-campaign replies) Aggregation of responses of all candidate initiatives

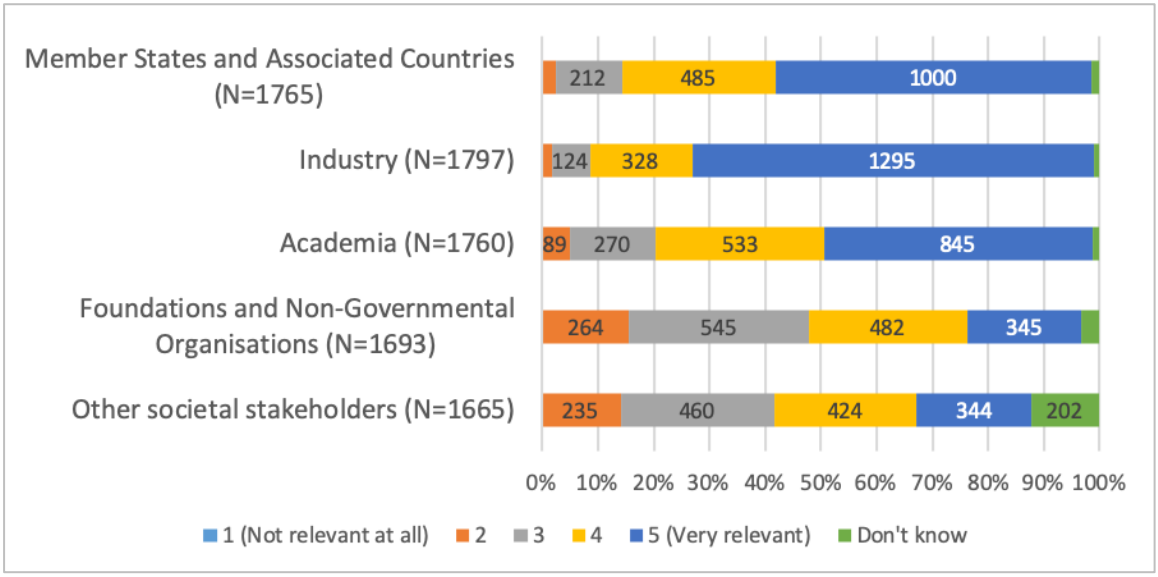


Pooling and leveraging resources through coordination, alignment and integration with stakeholders

Respondents were also asked how relevant it is for the proposed European Partnership to meet its objectives to pool and leverage resources (financial, infrastructure, in-kind expertise, etc.) through coordination, alignment and integration with specific groups of stakeholders. As shown in Figure 22 - similarly as for the previous questions-, respondents also see stakeholders from industry as the most relevant, followed by academia and governments (Member States and Associated Countries). The involvement of foundations and NGOs as well as other societal stakeholders are also still found to be (very) relevant for more than 50% of the respondents.

Similarly as described for the question on setting joint long-term agendas, most stakeholder categories valued their own involvement higher than other respondents – although also here differences between stakeholder categories were minor. As such, academic/research institutions see the relevance of academia higher, while large companies, SMEs and business association indicated a lower relevance of academia than other respondents. Similarly, these private sector stakeholders valued the relevance of industry higher than others while valuing the relevance of NGOs and other societal stakeholders less. NGOs value themselves and other societal stakeholders however higher than other respondents, and also public authorities indicated a higher relevance for Member States and Associated Countries then other respondents. Citizens mainly put more emphasis on the role of NGOs and other societal stakeholders then other respondents.

Figure 22: In your view, how relevant are the following elements and activities to ensure that the proposed European Partnership would meet its objectives – Pooling and leveraging resources (financial, infrastructure, in-kind expertise, etc.) through coordination, alignment and integration with: (non-campaign replies) Aggregation of responses of all candidate initiatives

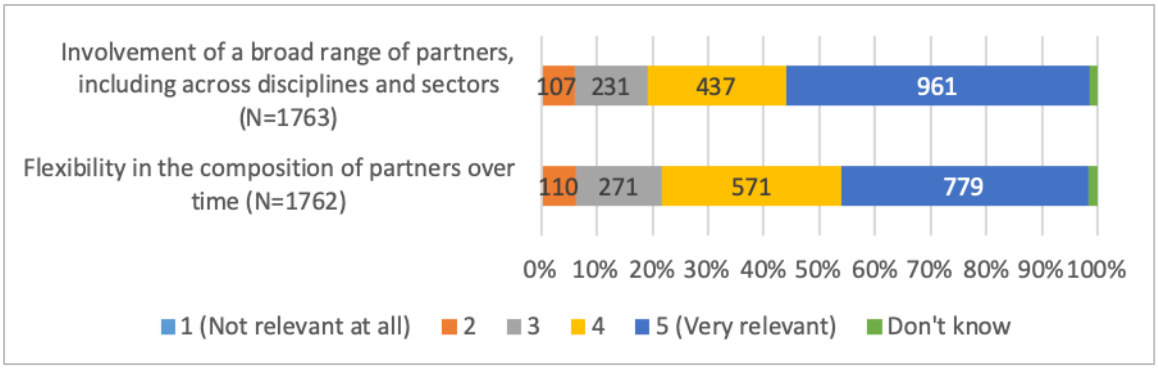


Composition of the partnerships

Regarding the composition of the partnership most respondents indicated that for the proposed European Partnership to meet its objectives the composition of partners needs to be flexible over time and that a broad range of partners, including across disciplines and sectors, should be involved (see Figure 23).

When comparing stakeholder groups only minor differences were found. Academic/research institutions and public authorities found the involvement of a broad range of partners and flexibility in the composition of partners over time slightly more relevant than other respondents, while large companies found both less relevant. SMEs mainly found the flexibility in the composition of partners over time less relevant than other respondents, while no significant differences were found regarding the involvement of a broad range of partners. Citizens provided a similar response to non-citizens. Respondents that are/were directly involved in a current/preceding partnership, when compared to respondents not involved in a current/preceding partnership, indicated a slightly lower relevance of the involvement of a broad range of partners and flexibility in the composition of partners over time.

Figure 23: In your view, how relevant are the following elements and activities to ensure that the proposed European Partnership would meet its objectives – Partnership composition (non-campaign replies) Aggregation of responses of all candidate initiatives

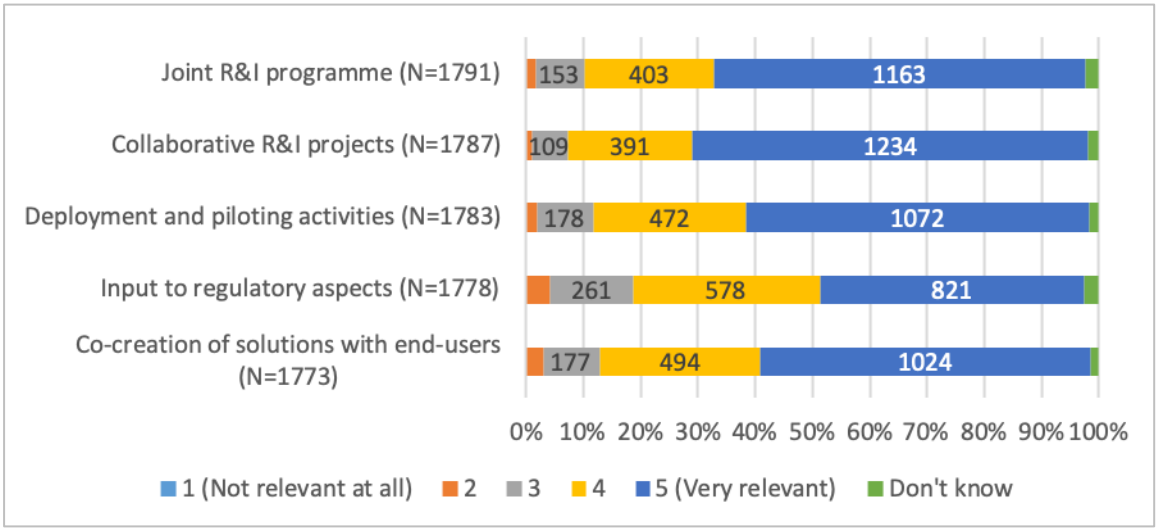


Implementation of activities

Most respondents indicated that implementing activities like a joint R&I programme, collaborative R&I projects, deployment and piloting activities, providing input to regulatory aspects and the co-creation of solutions with end-users are all (very) relevant for the partnerships to be able to meet its objectives (see Figure 24).

Minor differences were found between the main stakeholder categories, the differences found were in line with their profile. As such, academic/research institutions found joint R&I programme & collaborative R&I projects slightly more relevant and deployment and piloting activities, input to regulatory aspects and co-creation with end-users slightly less relevant than other respondents. For SMEs an opposite pattern is shown. Large companies, however, also found collaborative R&I projects slightly more relevant than other respondents, as well as input to regulatory aspects. The views of citizens are similar to non-citizens. Respondents that are/were directly involved in a current/preceding partnership, when compared to respondents not involved in a current/preceding partnership, show a slightly higher relevance across all activities shown in Figure 24.

Figure 24: In your view, how relevant are the following elements and activities to ensure that the proposed European Partnership would meet its objectives – Implementing the following activities (non-campaign replies) Aggregation of responses of all candidate initiatives



Relevance of setting up a legal structure (funding body) for the candidate European Partnerships to achieve improvements

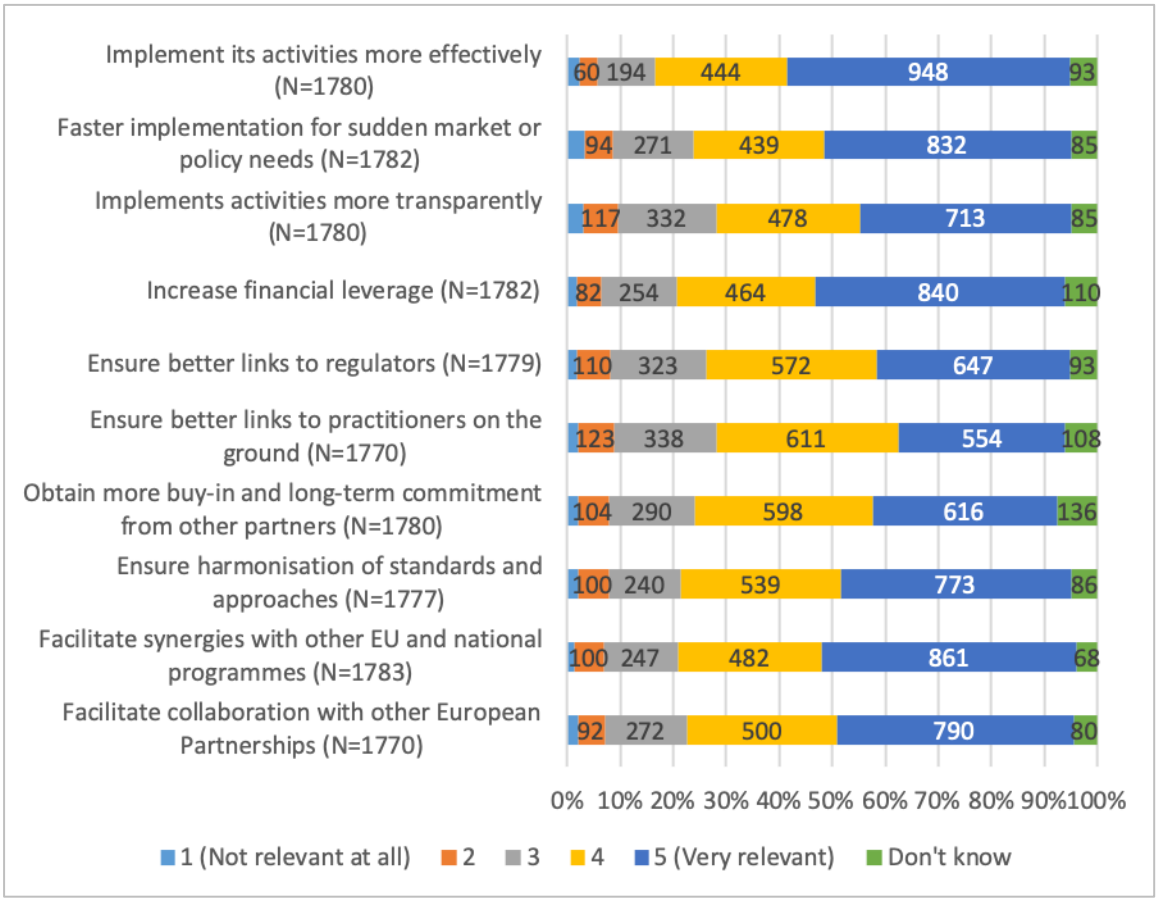
Respondents were then asked to reflect on the relevance of setting up a legal structure (funding body) for achieving a set of improvements, as presented in Figure 25. In general, 70%-80% of respondents find a legal structure (very) relevant for these activities. The legal structure was found most relevant for implementing activities in a more effective way and least relevant for ensuring a better link to practitioners on the ground, however differences are small.

When comparing the main stakeholder categories we found minor differences. Academic/research institutions indicated a slightly lower relevance for transparency, better links to regulators as well as obtaining the buy-in and long-term commitment of other partners. SMEs also indicated a lower relevance regarding obtaining the buy-in and long-term commitment of other partners. Large companies showed a slightly higher relevance for implementing activities effectively, ensure better links to regulators, obtaining the buy-in and long-term commitment of other partners, synergies with other EU/MS programmes and collaboration with other EU partnerships than other open consultation respondents. NGOs find it slightly more relevant to implement activities faster for sudden market or

policy needs. Public authorities, however, find it slightly less relevant to facilitate collaboration with other European Partnerships than other respondents.

The views of citizens show a slightly lower relevance for a legal structure in relation to implementing activities in an effective way. Quite different results are shown for respondents that are/were directly involved in a current/preceding partnership when compared to respondents not involved in a current/preceding partnership, they indicated a higher relevance across all elements presented in Figure 25.

Figure 25: In your view, how relevant is to set up a specific legal structure (funding body) for the candidate European Partnership to achieve the following? (non-campaign replies) Aggregation of responses of all candidate initiatives



Scope and coverage of the candidate European Partnerships based on their inception impact assessments

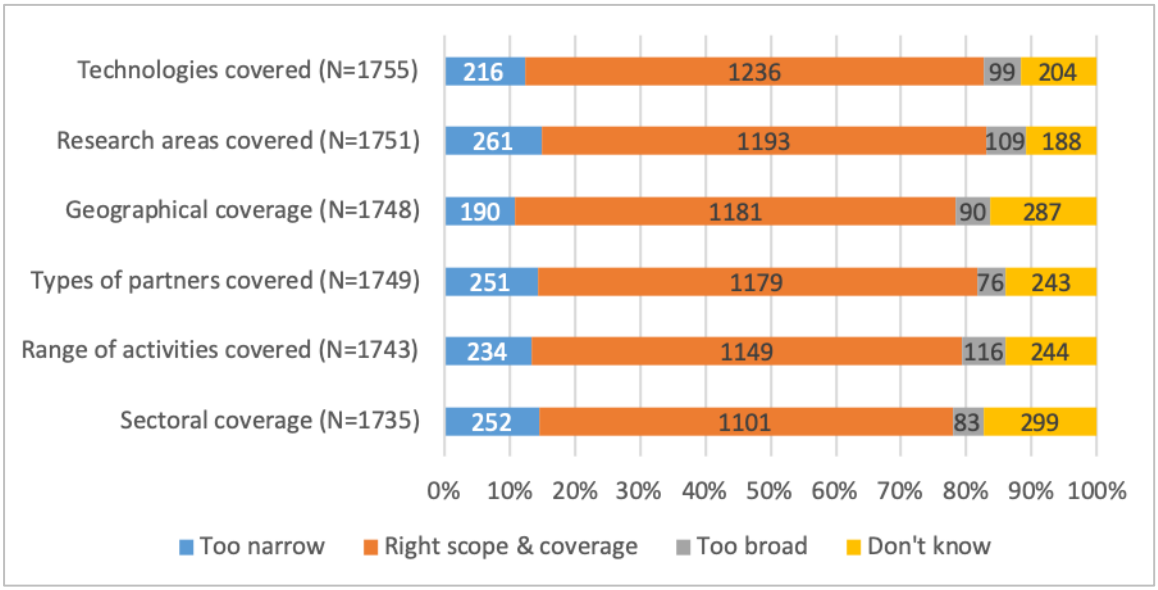
The response regarding the scope and coverage for the partnerships, based on inception impact assessments, shows that the large majority feels like the scope and coverage initially proposed in the inception impact assessments is correct. Figure 26 shows the results. However, about 11% to 15% of the respondents indicated the scope and coverage to be too narrow. About 11%-17% of respondents answered "Don't know". In the open answers respondents mostly reflected on specific aspects of the geographical and sectoral scope and coverage of the specific candidate European Partnerships, no overall lessons could be extracted.

Overall, differences between the main stakeholder categories were found to be minor. Academic/research institutions indicated slightly more often that the research area was "too narrow" then other respondents. SMEs on the other hand indicated slightly more often that the research area and the geographical coverage were "too broad". NGOs and public authorities, however, found the geographical coverage slightly more often "too narrow" when compared to other respondents. Large companies found the range of activities

slightly more often "too broad" and the sectoral focus slightly more often "too narrow" when compared to other respondents.

The views of citizens are the same as for other respondents. Most notably, respondents that are/were directly involved in a current/preceding partnership, when compared to respondents not involved in a current/preceding partnership, more often indicated that the candidate institutionalised European Partnership have the "right scope & coverage".

Figure 26: What is your view on the scope and coverage proposed for this candidate institutionalised European Partnership, based on its inception impact assessment? (non-campaign replies) Aggregation of responses of all candidate initiatives



Scope for rationalisation and alignment of candidate European Partnerships with other initiatives

When asked whether it would be possible to rationalise a specific candidate European Institutionalised Partnership and its activities, and/or to better link with other comparable initiatives, nearly two thirds of respondents answered "Yes" (1000, or 62.15%), while over one third answered "No" (609, or 37.85%). Nearly no differences were found between the main stakeholder categories, only large companies and SMEs indicated slightly more often "Yes" in comparison to other respondents.

The views of citizens are the same as for other respondents. Respondents that are/were directly involved in a current/preceding partnership, indicated "No" more often, the balance is about 50/50 between "Yes" and "No" for this group.

In the open responses respondents often referred to specific similar/comparable and complementary initiatives discussing the link with a specific candidate European Partnership, no overall lessons could be extracted, but more detailed results can be found in the partnership specific result sections.

Relevance of European Partnerships to deliver targeted scientific, economic/technological and societal impacts

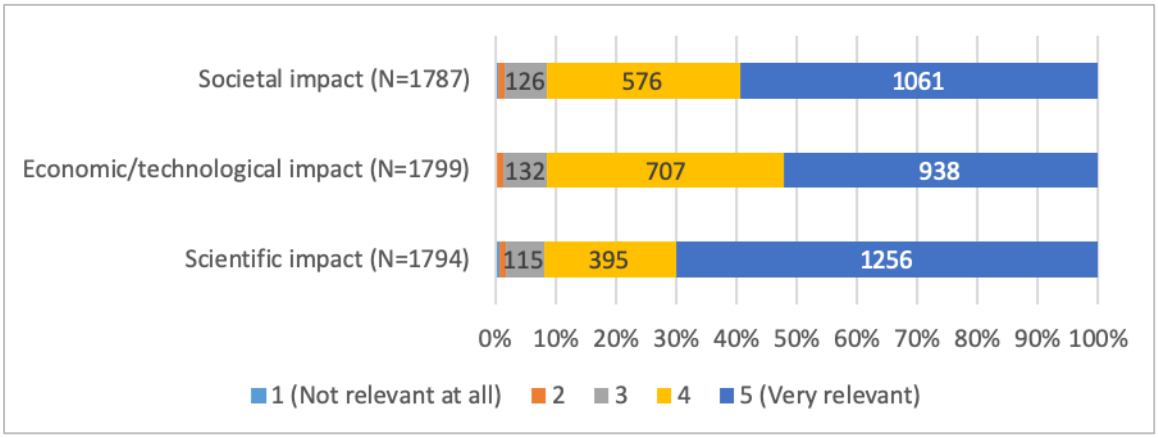
Finally, respondents were asked to rate the relevance of partnership specific impacts in three main areas: Societal impacts, Economic/technological impacts and Scientific impacts. To aggregate results the average of the responses on partnership specific impacts were calculated.

As presented in Figure 27, overall, all three areas were deemed (very) relevant across the candidate partnerships. Scientific impact was indicated as the most relevant impact, more than 90% of respondents indicated that these impacts were (very) relevant.

Only minor difference between stakeholder groups were found. Academic/research institutions found scientific impacts slightly more relevant, while large companies found economic and technological impacts slightly more relevant than other respondents. NGOs found societal impact slightly more relevant, while SMEs found this slightly less important.

Citizens, both EU and non-EU citizens, did not a significantly different view when compared to other respondents. Respondents that are/were directly involved in a current/preceding partnership find all impacts slightly more relevant than other respondents.

Figure 27: In your view, how relevant is it for the candidate European Institutionalised Partnership to deliver on the following impacts? (non-campaign replies) Aggregation of responses of all candidate initiatives



B.6 Responses to the open public consultation for the candidate partnership "Transforming Europe's Rail System"

B.6.1 Introduction

This section outlines the results of the Open Public Consultation for the candidate European Partnership for Transforming Europe's Rail System. The section outlines the following:

- Results on general questions, segregated for this candidate European Partnership:
  - Views on the needs of the future European Partnerships under Horizon Europe
  - Views on the advantages and disadvantages of participation in an Institutionalised European Partnership
- Results on specific questions for this candidate European Partnership:
  - Relevance of research and innovation efforts at the EU level to address problems
  - Views on Horizon Europe interventions to address these problems
  - Views on the relevance of elements and activities in: setting a joint long-term agenda; pooling and leveraging resources; partnership composition; implementation of activities.
  - Views on setting up a specific legal structure (funding body)
  - Views on the proposed scope and coverage of this candidate European Partnership
  - Views on the alignment of the European Partnership with other initiatives
  - Relevance of this candidate European Partnership to deliver impacts

B.6.2 Characteristics of respondents

There are 151 respondents who have answered (part of) the consultation for the Transforming Europe's rail system Partnership. Of these respondents, 32 (21.19%) were citizens. The largest group of respondents were businesses with 62 (41.06%) respondents. There were 29 respondents from academic and research institutions (19.21%) and 14 from business associations (9.27%). 7 respondents were from public authorities (4.64%). The remaining respondents were from NGO's (2, 1.32%), consumer organisations (1, 0.66%) and other (4, 2.65%). Over two-thirds of respondents, namely 106 (70.20%), have been

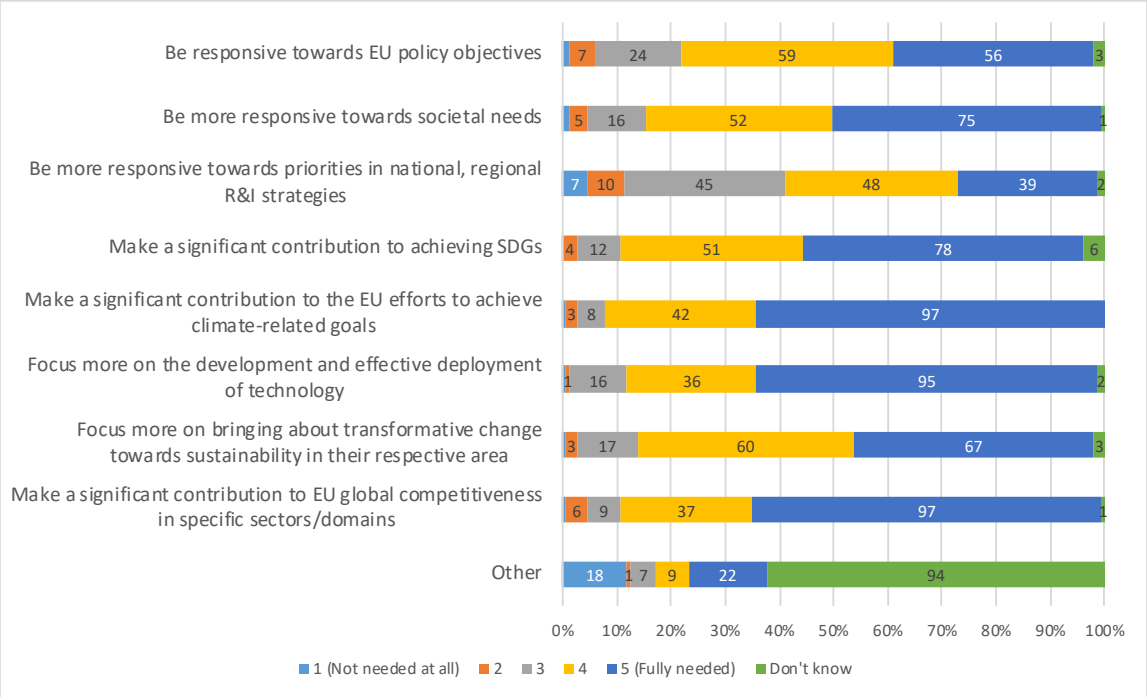
involved in the on-going research and innovation framework programme, of which 85 respondents (80.19%) were directly involved in a partnership under Horizon 2020 or its predecessor Framework Programme 7.

B.6.3 Characteristics of future candidate European Partnerships – as viewed by respondents to the Transforming Europe's Rails System initiative

At the beginning of the consultation, the respondents of this partnership indicated their views of the needs of the future European Partnerships under Horizon Europe. All 151 respondents answered this question. Overall, respondent indicated that many of the options that were presented were fully needed. The needs where most respondents indicated this, was making a significant contribution to the EU efforts to achieve climate-related goals (97, 64.24%) and focusing more on the development and effective deployment of technology (95, 62.91%). Aside from 'other', the need where the least respondents indicated that improvements were fully needed, was being more responsive towards priorities in national regional and R&I strategies (39, 25.83%). For this option, more respondents indicated a 3 out of the 5 point scale than respondents who chose fully need.

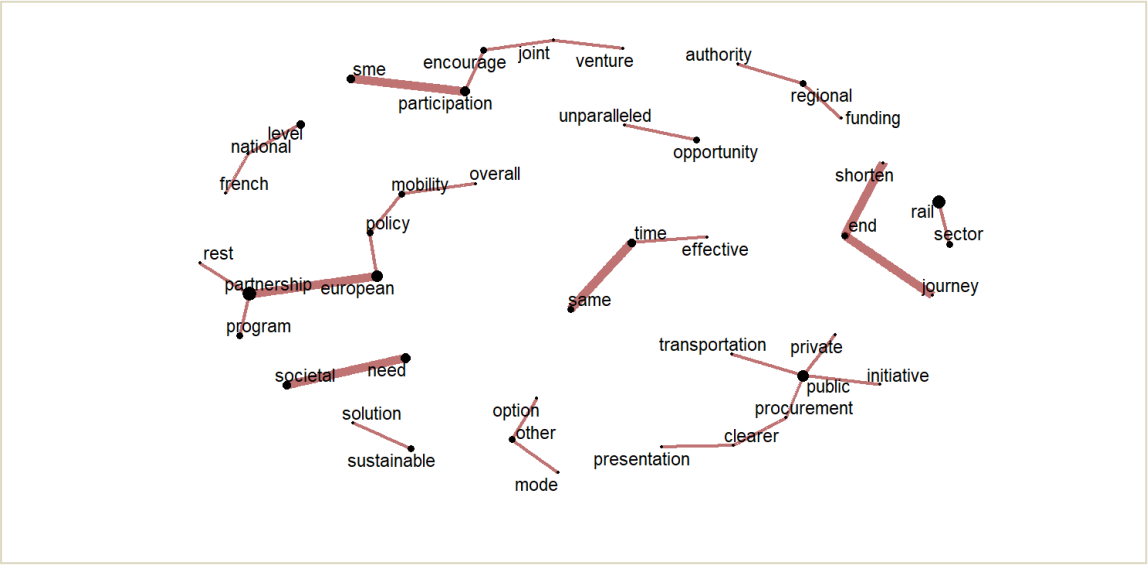
No statistical differences were found between the views of citizens and other respondents.

Figure 28: Views of the respondents in regard to the needs of future European Partnerships under Horizon Europe (N=151)



The respondents also had the option to indicate other needs. The results of the analysis resulted in the chart shown in Figure 29 showing the co-occurrences of keywords. The results show that respondents have indicated needs around the encouragement of SME participation, shortening end journeys and societal needs.

Figure 29: Assessment of open answers of other needs, 30 most common co-occurring keywords (N=51)



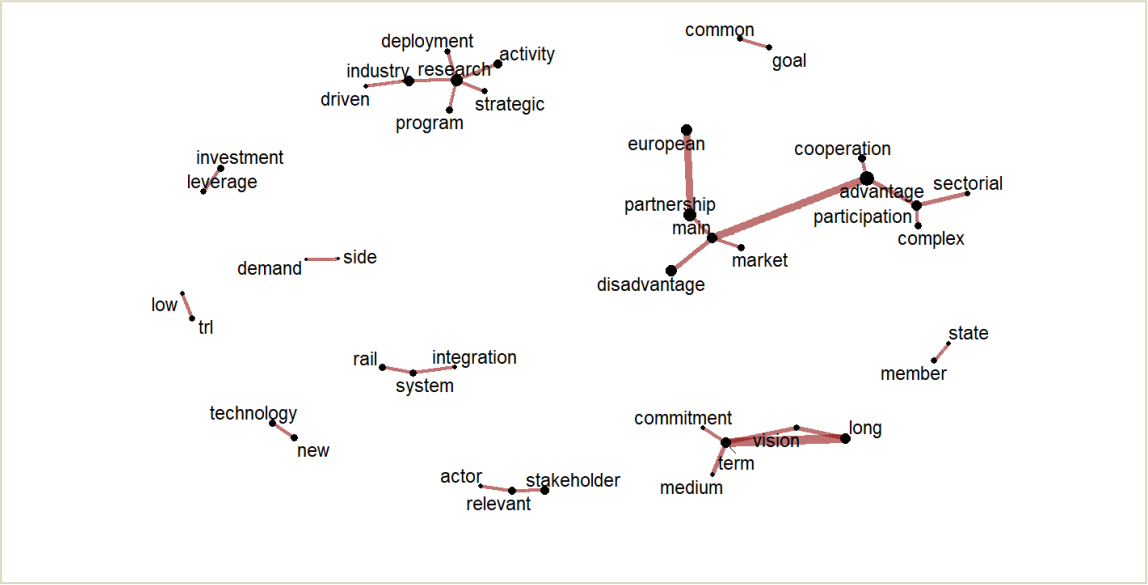
Some of the key themes emerging from the responses to the open questions included the following:

- Both companies and academic institutions highlighted the importance of ensuring the competitiveness of the European rail industry at the global level while focusing on societal objectives (e.g. increasing the use of renewable resources) and demonstrating the practical benefits of rail-related R&I to a wide audience.
- EU citizens identified a range of other needs, including encouraging joint ventures and the participation of SMEs and communicating the key role of the EU in implementing the partnership (with a view to building awareness of the importance of cooperation within the rail sector at the European level).

B.6.4 Main advantages and disadvantages of Institutionalised European Partnerships

The respondents were asked what they perceived to be the main advantages and disadvantages of participation in an Institutionalised European Partnership (as a partner) under Horizon Europe. The keyword analysis used for open questions resulted in the graph shown in Figure 30. This analysis showed the respondents viewed cooperation as an advantage, as well as mentioning long term vision and commitment.

Figure 30: Assessment of open answers with advantages and disadvantages of participation in an Institutionalised European Partnership, 30 most common co-occurring keywords (N=129)



Companies of all sizes emphasised the advantages of collaboration, including between organisations that compete with one another, and effective coordination of R&I activity throughout a project's life cycle to drive innovation in what can be a conservative industry. They also identified optimal management of projects, the ability to develop a long-term vision and continuity, stability and visibility of projects as important benefits of participation in an institutionalised partnership.

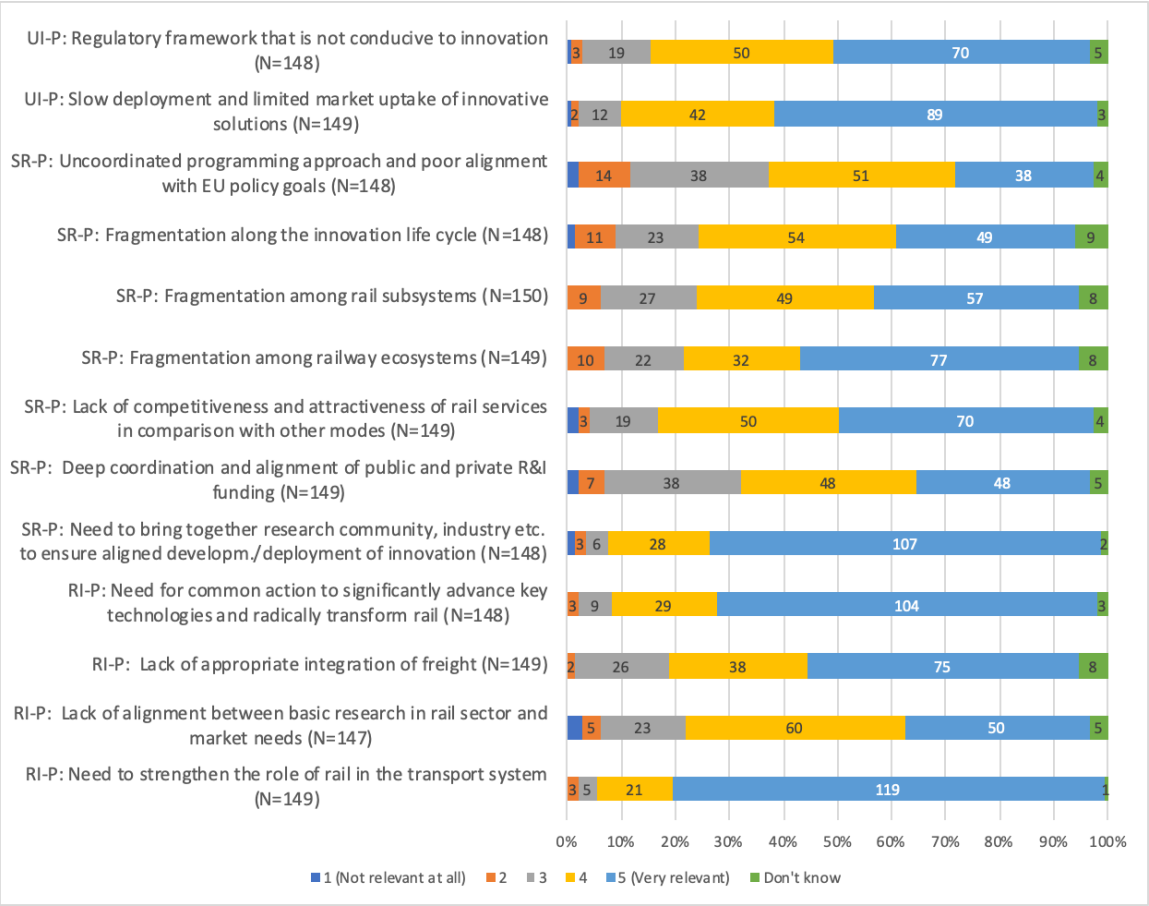
Academic institutions noted the benefits of building relationships with the rail industry and of pursuing research with practical application to the sector. However, they also noted that some research activities are best conducted in collaboration with a single partner rather than a large number of organisations.

EU citizens highlighted a number of advantages of an institutionalised partnership, including collaborative working to develop a standardised platform for innovation, dedicated funding and the ability to develop a long-term strategy. At the same time, they noted some disadvantages, including the risk of establishing an industry-driven 'closed shop' and undue focus on projects with high technology readiness levels (and the associated neglect of more fundamental research).

B.6.5 Relevance of EU level efforts to address problems in relation to the Transforming Europe's Rail System initiative

In the consultation, respondents were asked to provide their view on the relevancy of research and innovation efforts at EU level to address the following problems in relation to rail systems, specifically on three types of problems: problems in uptake of rail system innovations and services (UI-P), structural and resource problems (SR-P) and research and innovations problems (RI-P). In Figure 31 the responses to these answers are presented.

Figure 31: Views of respondents on relevance of research and innovation efforts at the EU level to address problems in relation to rail systems



With regard to the uptake in innovation problems, 89 respondents have indicated that they view research and innovation efforts at EU level to address the slow deployment and limited market uptake of innovative solutions as very relevant (59.73%).

With regard to structural and resource problems, the respondents have given differing answers. The problem that was viewed as most relevant to be addressed at EU level, was the need to bring together rail research community, supply industry and operators/infrastructure managers, to ensure aligned development and development of innovation. A 107 respondents (72.30%) have indicated that this problem is very relevant. The structural and resource problem that was seen as the least relevant of all the problems that the respondents were asked to reflect on, only 38 respondents (25.68%) have indicated that this is a very relevant problem to address at EU level.

The Research and Innovation problem where most respondents have indicated that it is very relevant, is the need to strengthen the role of rail in the transport system. A 119 respondents (79.87%) have indicated this is very relevant, the most of any of the problems the respondents were asked to reflect on.

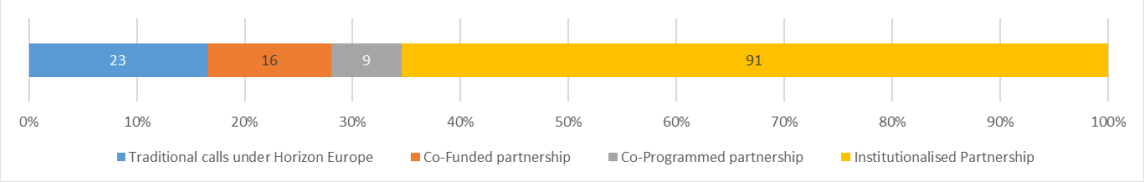
No statistical differences were found between the views of citizens and other respondents for most problems. Citizens, however, found the research and innovations problem related to the need to strengthen the role of rail in the transport system more relevant and the structural and resource problem related to the fragmentation along the innovation life cycle less.

B.6.6 Horizon Europe mode of intervention to address problems

After providing their views on the relevance of problems, respondents were asked to indicate how these challenges could be addressed through Horizon Europe intervention. As shown in Figure 32, just over 65% of respondents indicated that institutionalised partnerships were the best fitting intervention.

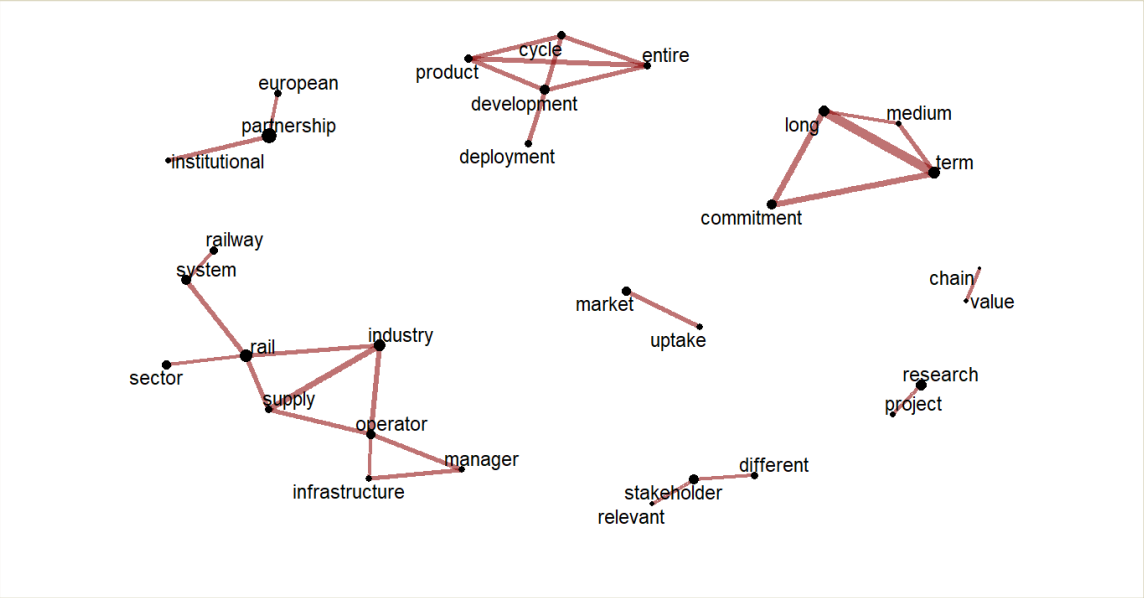
No statistical differences were found between the views of citizens and other respondents.

Figure 32: Assessment of Horizon Europe intervention



The respondents were asked to briefly explain their answers to the question above. People who stated that an institutionalised partnerships was the best fitting answer, the entire product development cycle, long term commitment and market uptake (Figure 33). Respondents who did not select institutionalised partnership as their preferred intervention (N=43) mentioned traditional calls, rail innovation, public and private rail sector and bound funding (not pictured).

Figure 33: Assessment of open answers to explain their choice institutionalised partnership in the assessment of the Horizon Europe intervention, 30 most common co-occurring keywords (N=76)



In their open responses, stakeholders gave a number of reasons for supporting an institutionalised partnership as the most effective way of addressing the challenges posed by R&I in the rail sector:

- A number of respondents, including companies, business associations and public authorities, noted that, based on recent experience, only an institutionalised partnership could ensure the level of coordination needed to enable collaboration across a wide range of partner organisations, and that such a partnership would provide the governance and funding framework required to secure their participation.
- EU citizens highlighted the potential for an institutionalised partnership to support the de-carbonisation agenda through engagement with national governments and with other EU initiatives focused on exploitation of clean forms of energy.

However, there was some support for co-financing from at least one academic institution on the grounds that it would encourage R&I activities focused on the interests of rail users.

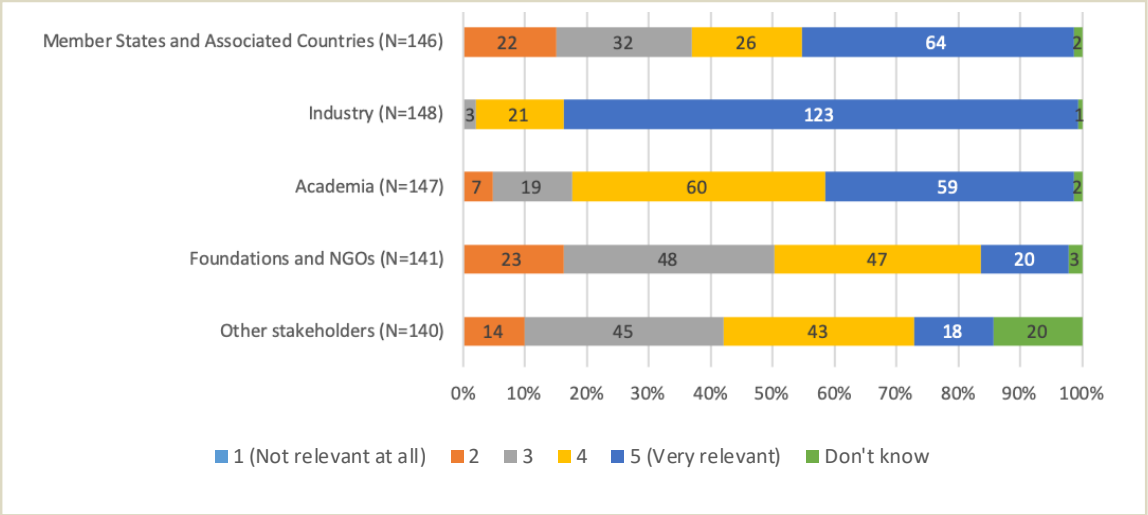
B.6.7 Relevance of a set of elements and activities to ensure that the proposed European Partnership would meet its objectives

Setting joint long-term agendas

Respondents were asked how relevant the involvement of actors is in setting a joint long-term agenda to ensure that the proposed European Partnership would meet its objectives (Figure 34). The highest amount of respondents indicated that the involvement of Industry is very relevant (123 respondents or 83.11%). Less than half of respondents (64, 43.84%) indicated that the involvement of Member States and Associated Countries is very relevant, with 40.14% of respondents indicating that the involvement of academia was very relevant. Respondents considered the involvement of foundations and NGO's and other stakeholders less relevant, with both options being seen as very relevant by around 10% of respondents (14.18% and 12.86% respectively).

Citizens, as compared to other respondents, found government (Member States and Associated Countries) and foundations and NGOs slightly more relevant. Respondents that are/were involved in a current/preceding partnership (Horizon 2020 or Framework Programme 7) found industry more relevant.

Figure 34: Views of respondents on relevance of actors in setting a joint long-term agenda

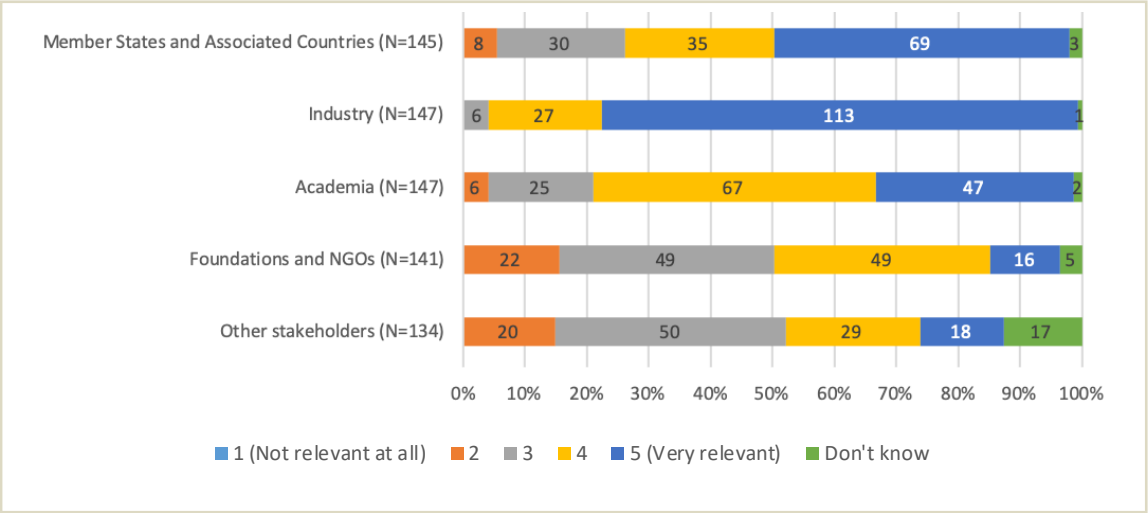


Relevance of elements and activities in pooling and leveraging resources

With respect to the relevance of actors in pooling and leveraging resources, such as financial, infrastructure, in-kind expertise etc.), to meet Partnership objectives, the patterns are similar. First, 113 respondents (76.87%) indicated that industry was very relevant, which is much larger than for any of the other stakeholders. 69 (47.59%) respondents felt that Member States and Associated Countries were very relevant and 47 (31.97%) of respondents indicated that Academia were very relevant. Foundations and other stakeholders were deemed less relevant, since only 16 (11.35%) and 18 (13.43%) respondents respectively indicated that these stakeholders were very relevant. No respondents indicated that any of the categories was Not relevant at all.

Citizens, as compared to other respondents, found foundations and NGOs slightly more relevant.

Figure 35: Views of respondents on relevance of actors for pooling and leveraging resources

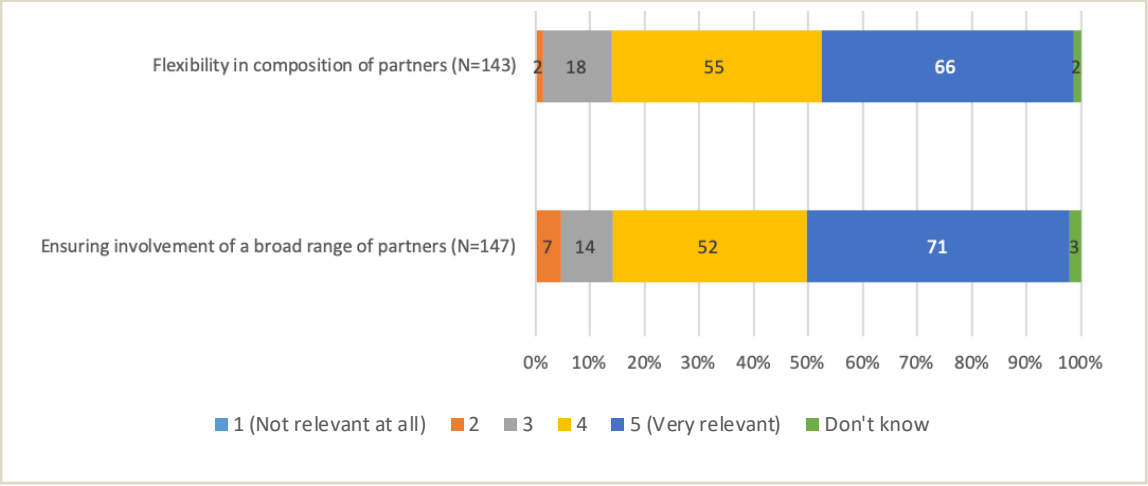


Relevance of elements and activities for the partnership composition

Respondents were asked about the relevance of Partnership composition, such as flexibility in the composition of partners over time and involvement of a broad range of partners (including across disciplines and sectors), to reach Partnership objectives. As it is visible in Figure 36, the answers are similar. Ensuring involvement of a broad range of partners has slightly more 'very relevant' answers (71, 48.30%) than the flexibility in the composition of partners (66, 46.15%). Interestingly 84.62% of respondents have given flexibility either a score of 4 or 5 (very relevant) which is slightly higher than the 83.67% who have given the broad range of partners a score of 4 or 5 (very relevant).

No statistical differences were found between the views of citizens and other respondents.

Figure 36: Views of respondents on relevance of partnership composition elements

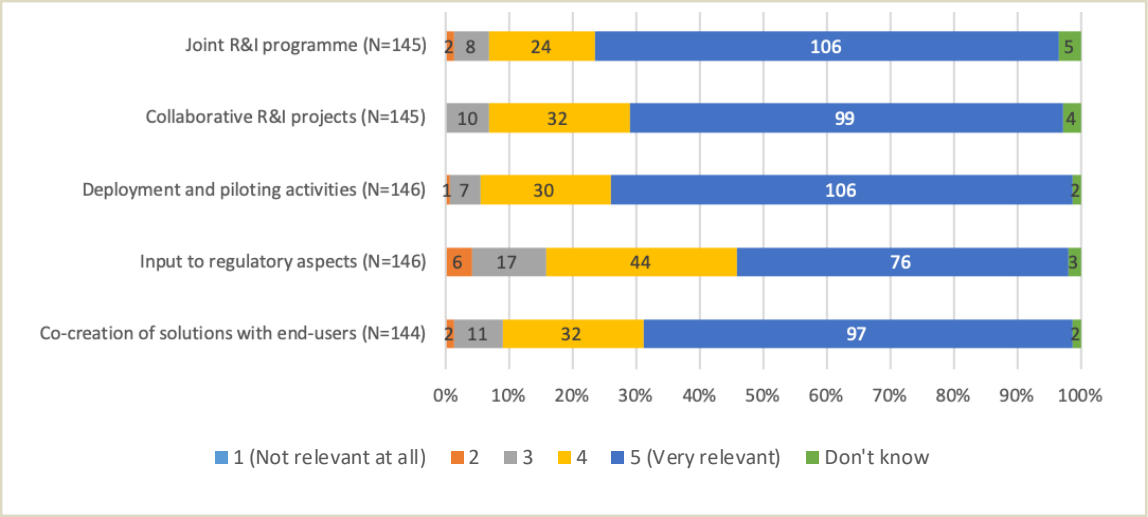


Relevance of implementation of activities

Respondents were asked to provide opinions on relevance of implementation of several activities for meeting objectives of the Transforming Europe's Rail System Partnership. Among activities were listed – joint R&D programme, collaborative R&D projects, deployment and piloting activities, input to regulatory aspects and co-creation of solutions with end-users. Out of 145 respondents, 106 (73.10%) indicated that deployment and piloting activities and a Joint R&I programme are very relevant to ensure that the Partnership would meet its objectives. For all the other options, the majority (over 50%) of all respondents have indicated that these are very relevant.

No statistical differences were found between the views of citizens and other respondents.

Figure 37: Views of respondents on relevance of implementation of the following activities

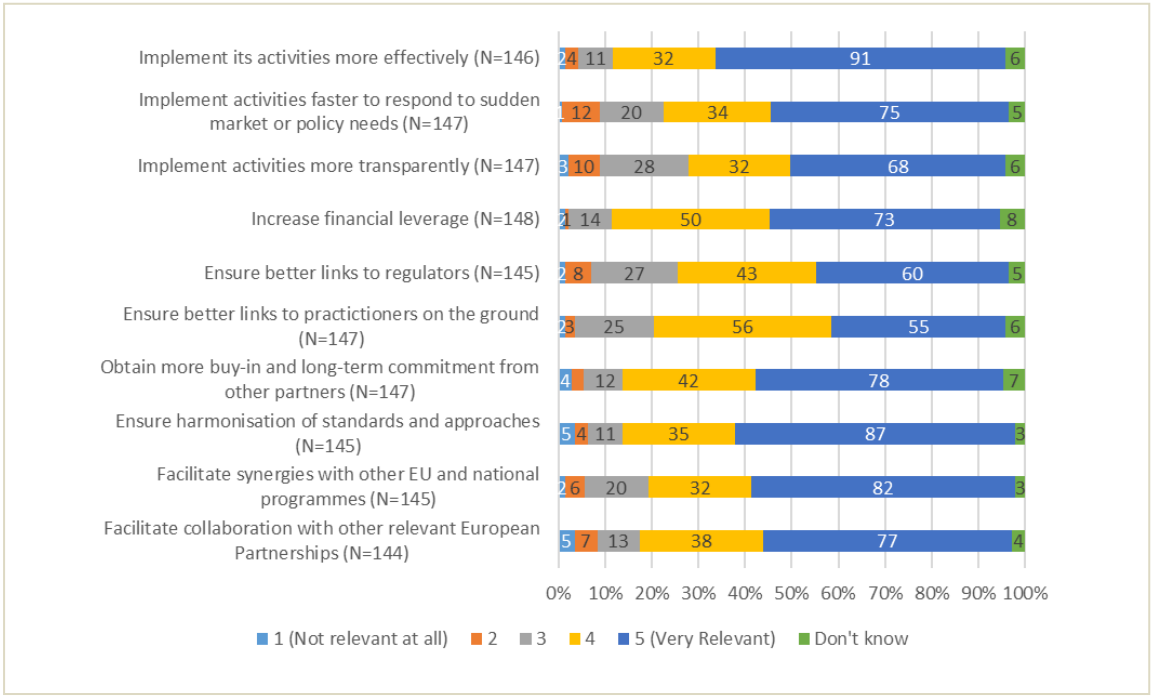


B.6.8 Relevance of setting up a legal structure (funding body) for the candidate European Partnerships to achieve improvements

Respondents were also asked to assess the relevance of a specific legal structure (funding body) for the candidate European Partnership to achieve several activities. According to Figure 38, respondents indicated that it was very relevant to set up a specific legal structure for the partnership to achieve a more effective implementation of activities (91, 62.33%) and to ensure harmonisation of standards and approaches (87, 60.00%). Ensuring better links to practitioners on the ground has received the least 5 (very relevant) responses, however it has received the most 4's, which indicates that it is still seen as relevant by the respondents even if it is slightly less relevant than the other options.

No statistical differences were found between the views of citizens and other respondents. Respondents that are/were involved in a current/preceding partnership found a legal structure more relevant than other respondents when it concerned a faster to response to sudden market or policy needs as well as synergies with other programmes and collaboration with other partnerships.

Figure 38: Views of respondents on relevance of a specific legal structure

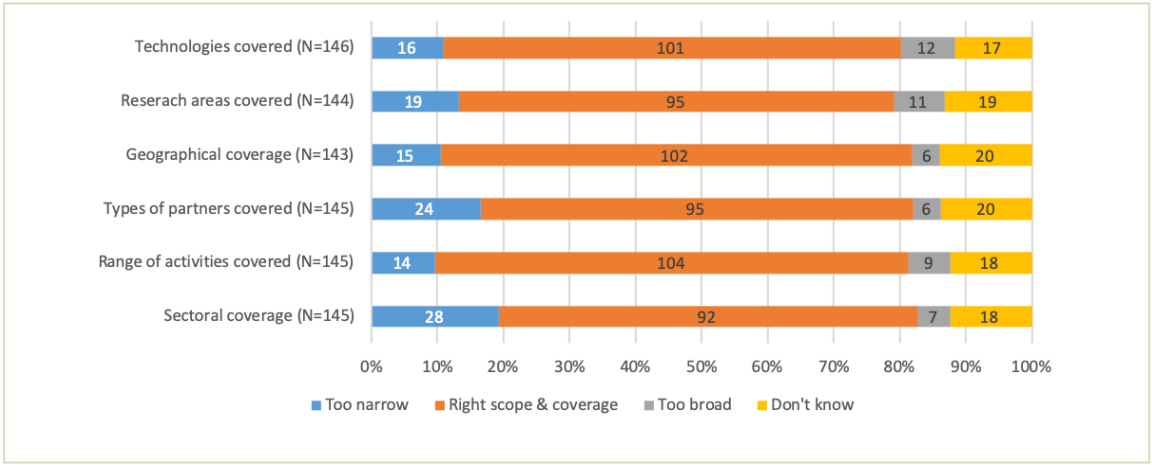


B.6.9 Scope and coverage of the candidate European Partnerships based on their inception impact assessments

Respondents were asked to assess the scope and coverage of the Transforming Europe's Rail System Partnership, based on its inception impact assessment. The clear majority of the respondents have indicated that the partnership has the right scope and coverage across all areas. The respondents have been the most positive with regard to the range of activities covered, where 104 respondents (71.72%) have indicated the partnership has the right scope and coverage. The respondents who have indicated that the scope and coverage are not right, have indicated that it was too narrow more often than they viewed it as too broad.

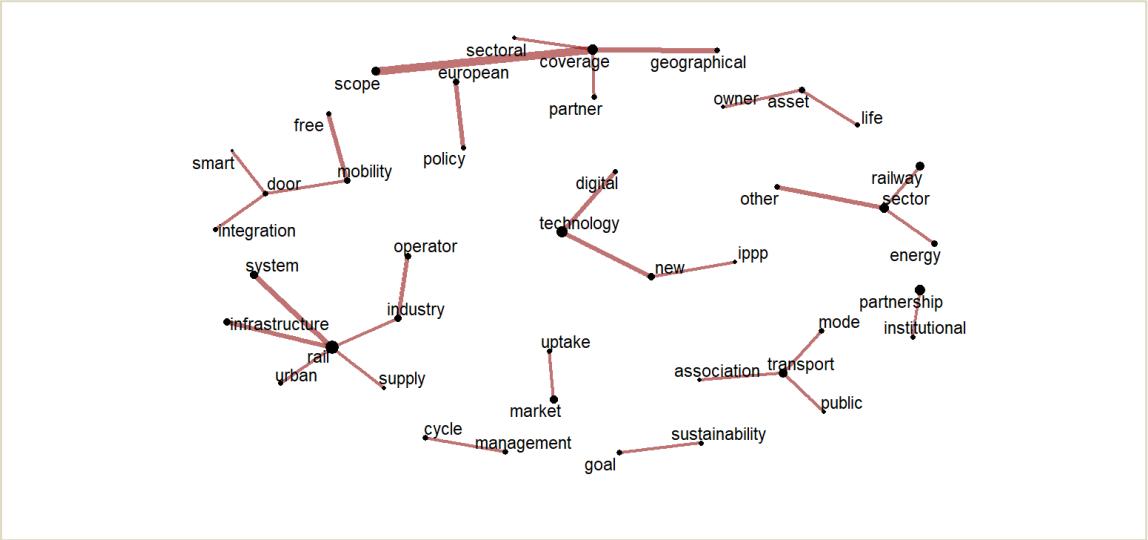
No statistical differences were found between the views of citizens and other respondents.

Figure 39: Views of respondents on the scope and coverage proposed for the Transforming Europe's Rail System Partnership



Aside from this multiple choice question, the respondents were also asked to provide any comment that they may have on the proposed scope and coverage for this candidate Institutionalised Partnership. The keyword analysis used for open questions resulted in the graph shown in Figure 40. This analysis showed the respondents used this question to talk about geographical coverage and scope, new digital technologies and rail infrastructure.

Figure 40: Assessment of open answers with regard to the proposed scope and coverage for this candidate Institutionalised Partnership, 30 most common co-occurring keywords (N=62)



Companies responding to the open questions emphasised the importance of a broad scope of activity in terms of:

- Projects relevant to the whole of Europe, avoiding undue focus on technical solutions appropriate only for western European countries;
- Technical focus (with projects covering intelligent maintenance, asset life cycle management, applications of digital technology and integration of different transport modes); and
- Coverage of different types of rail transport (including urban rail and light rail).

However, one company respondent expressed a preference for establishing a limited number of programmes with a view to obtaining results more quickly.

Academic institutions also indicated a preference for a broad scope of activity, encompassing areas of R&I identified by ERRAC and integrating national programmes. One noted the importance of including transport logistics in the scope of work.

EU citizens highlighted the importance of learning from the experience of Shift2Rail in defining the scope of the institutionalised partnership's activity.

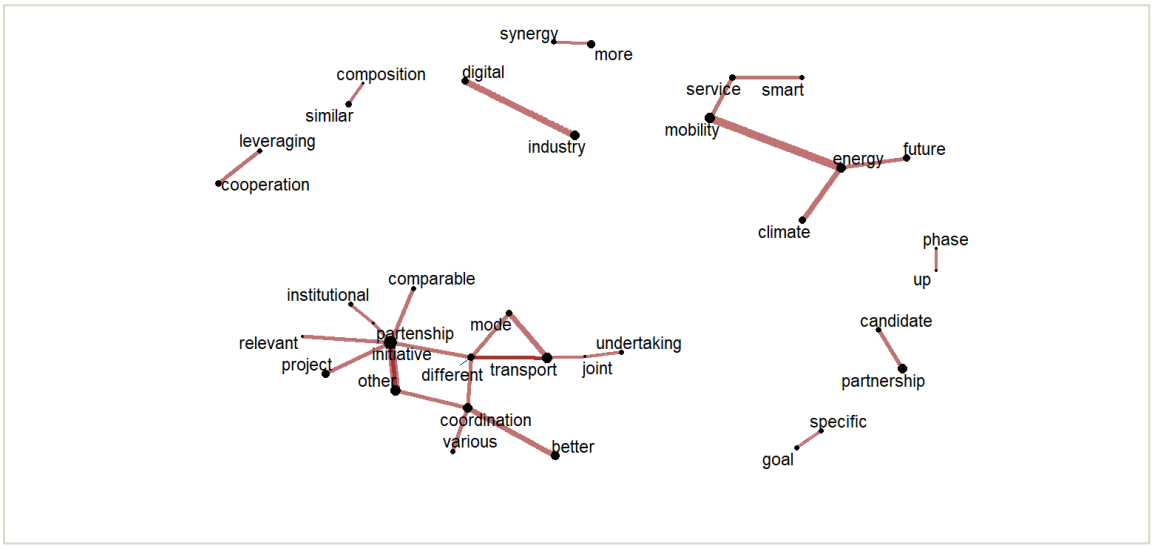
B.6.10 Scope for rationalisation and alignment of candidate European Partnerships with other initiatives

The respondents were also asked if it they thought it would be possible to rationalise the candidate European Institutionalised Partnership and its activities, and/or to better link it with other comparable initiatives. 95 respondents (68.84%) have indicated that they think this is the case.

No statistical differences were found between the views of citizens and other respondents.

The respondents who answered affirmative, where asked which other comparable initiatives it could be linked with. The results of the analysis resulted in the chart shown in Figure 41 showing the co-occurrences of keywords. The results show that respondents mention energy mobility and the future of energy as well as digital industry and comparable partnerships and joint undertakings in transport.

Figure 41: Assessment of open answers on the question on which other comparable initiatives it could be linked with, 30 most common co-occurring keywords (N=56)

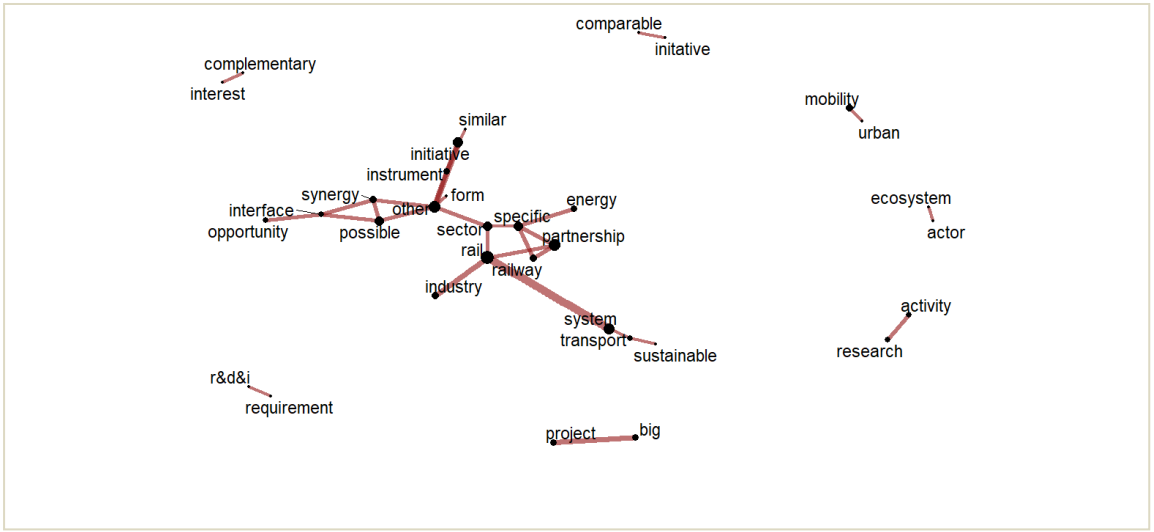


A review of a sample of the responses to the open questions indicated the following:

- Companies were not persuaded that the partnership should be rationalised, noting that continuity of the existing broad organisational structure would help to ensure that stakeholders continued to participate. However, they supported the case for establishing links with other relevant initiatives, including other partnerships within the Climate, Energy and Mobility Cluster and initiatives focused on sustainability and the development of multi-modal transport solutions.
- EU citizens as well as other organisations similarly supported greater coordination of the activities of different initiatives while stopping short of endorsing substantial rationalisation of institutions. One academic institution noted the potential for synergy with the Clean Sky and SESAR partnerships as well as with initiatives focusing on road transport and digital solutions.

For the respondents who answered negatively on the previous question, the results of the analysis resulted in the chart shown in Figure 42 showing the co-occurrences of keywords. The results show that respondents mention specific partnerships related to energy, railway system and the railway industry as well as comparable initiatives and the possibility of synergy.

Figure 42 Assessment of open answers on the question why other comparable initiatives are not suitable to be linked, 30 most common co-occurring keywords (N=21)



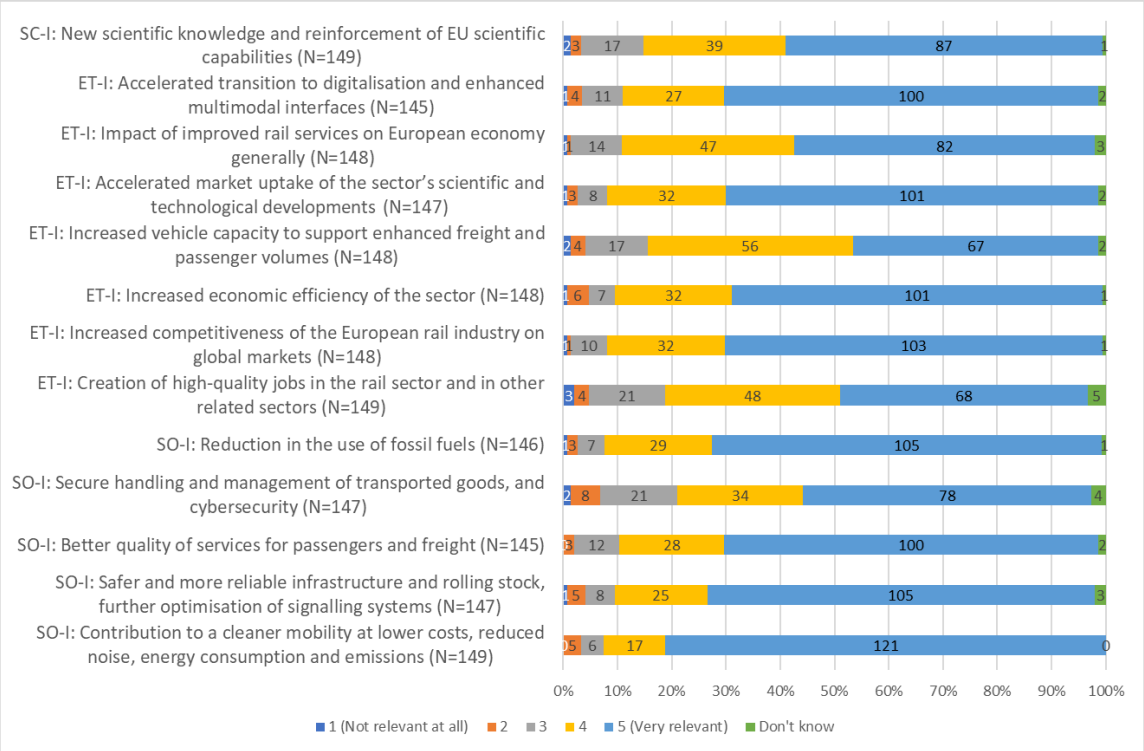
Some respondents argued that both a rationalisation of partnerships and more links with other initiatives would be counter-productive. For example, one academic institution noted that too many links with other initiatives could result in a loss of focus while an EU citizen suggested that the primary focus should be on integration of work programmes within the institutionalised partnership itself. However, even among respondents expressing doubts about the potential for synergy and links with other initiatives, most indicated that some interaction with partnerships focused on carbon reduction as well as with initiatives concerned with transport would be beneficial.

B.6.11 Relevance of European Partnerships to deliver targeted scientific, economic/technological and societal impacts

Respondents were asked to assess the relevance of the candidate European Institutionalised Partnership to deliver on listed impacts, see Figure 43. Among presented societal impact categories, a higher number of respondents, namely 121 out of 149 (81.21%), indicated that the Partnership would be 'very relevant' for contributing to a cleaner mobility at lower costs, reduced noise, energy consumption and emissions. Among economic/technological impacts, several categories were considered as 'very relevant' by around 70% of respondents. In contrast, the lowest number of respondents (namely, 67 and 68 respectively) suggest that the candidate Partnership would have a significant impact on increase of vehicle capacity to support enhanced freight and passenger volume, and on creation of high-quality jobs in the rail sector and in other related sectors. The only listed scientific impact category ("new scientific knowledge and reinforcement of EU scientific capabilities") received the highest score (5 'very relevant') by 87 out of 149 respondents (58.39%).

No statistical differences were found between the views of citizens and other respondents.

Figure 43: Views of respondents on the relevance of the candidate European Institutionalised Partnership to various impacts



B.6.12 Summary of campaigns results for this specific initiative

The current candidate Partnership received 29 similar responses, which are treated as part of a campaign (campaign #4).

Table 31: Overview of responses of campaign participants (N=29)

Question category	Summary of responses
Research and innovation problems	All answer categories are considered either 'very relevant' or 'relevant'. Among categories, the lowest score was given to "lack of alignment between basic research in rail sector and market needs".
Structural and resource problems	Most categories are considered either 'very relevant' or 'relevant' by consultation respondents. The lowest score (on average, 3) is given to the following categories: "deep coordination and alignment of public and private R&I funding" and "uncoordinated programming approach and poor alignment with EU policy goals".
Problems in uptake of digital innovations	The categories "slow deployment and limited market uptake of innovative solutions" received a high score (either 4 or 5). The other category ("regulatory framework that is not conducive to innovation) received mixed scores – ranging from 2 to 5.
Preferred Horizon Europe intervention	Institutionalised Partnership was selected by all respondents. When respondents were asked to explain their choice, all of them used different versions of the following quote: *"Partnership supports bringing together supply Industry, operators, infrastructure managers and research centers and foster long-term commitments of all actors to ensure aligned specifications, development and deployment of innovations. Institutionalised Partnership covers product development cycles, prevents fragmentation among rail ecosystems and accelerates innovations"*.
Relevance of actors for setting join long-term agenda	Most answer categories received an average score (namely, 3) on the scale of 1 to 5. However, industry is considered 'very relevant' by the majority of respondents.
Relevance of actors for pooling and leveraging resources	Most answer categories received an average score (namely, 3) on the scale of 1 to 5. However, industry is considered 'very relevant' by the majority of respondents.
Partnership composition	Respondents consider the listed elements of partnership composition to be 'relevant' (score 4).
Implementation of activities	Almost all respondents rated all listed activities 'very relevant'.
Relevance of the legal structure	Across all categories, respondents indicated that the legal structure would be relevant. Almost all respondents consider that the legal structure would be 'very relevant' to implement activities of the Partnership more effectively, to implement activities faster to respond to sudden market or policy needs, to facilitate synergies with other EU and national programmes, to facilitate collaboration with other relevant European Partnerships, and to obtain more buy-in and long-term commitment from other partners.
Scope and coverage of the candidate Partnership	All respondents considered that listed components of the candidate Partnership have right scope and coverage, with the exception of sectoral coverage. In that answer category, almost a third of respondents indicated that the scope and coverage are too narrow. Respondents were offered an opportunity to provide comments on the proposed scope and coverage of the Institutionalised Partnership. All of them included the following quote: *"Programme of the rail iPPP shall be aligned with the vision of the rail sector presented: ERRAC*

Question category	Summary of responses
	2050 and ERRAC 2030 R&I priorities. Key research areas: Assets for Automatic and Autonomous Operations, Rail Digitalisaiton, Maintenance of the future (including required equipment), Smart Integration for Door to Door Mobility, Multi-Modality, Environmental Sustainability and Carbon Free Mobility, Rail Freight, Network & Asset Management. Deployment shall also be included to speed up market uptake".
Rationalisation of the candidate Partnership and linking to other initiatives	The majority of respondents (18, or 64.29%) consider that it would be possible to rationalise the candidate Partnership and its activities, and/or to better link it with other comparable initiatives. Respondents were asked to explain their answer. Regardless of their answer choice, all of them inserted a following quote: *"We do not consider possible nor sensible to rationalise further the proposed candidates for Institutionalised Partnerships. The competitiveness and industrial leadership of Europe would be, otherwise, hampered. However, we support ensuring better coordination between the different proposed initiatives. In particular, in the case of rail, coordination with the other initiatives falling within Clusters ''Climate, Energy, Mobility'' and ''Digital, Industry and Space'' would be important".*
Societal impact	Majority of respondents considered that the candidate Partnership would be 'very relevant' to deliver on the listed societal impact.
Economic/technological impact	Most respondents consider that the candidate Partnership would be "very relevant for the following impacts: "increased competitiveness of the European rail industry on global markets", "increased economic efficiency of the sector", "accelerated market uptake of the sector's scientific and technological developments" and "accelerated transition to digitalisation and enhanced multimodal interfaces". Other categories, on average, received a score of 4.
Scientific impact	Most respondents consider that the candidate Partnership is 'very relevant' and 'relevant' for delivering on listed scientific impacts.

Appendix C Methodological Annex

C.1 Methodological approach common to all the impact assessment studies for the 13 candidate institutionalised European Partnerships

The Impact Assessment studies for all 13 candidate institutionalised European Partnerships mobilised a mix of qualitative and quantitative data collection and analysis methods. These methods range from desk research and interviews to the analysis of the responses to the Open Consultation, stakeholder analysis and composition/portfolio analysis, bibliometrics/patent analysis and social network analysis, and a cost-effectiveness analysis.

The first step in the impact assessment studies consisted in the definition of the context and the problems that the candidate partnerships are expected to solve in the medium term or long run. The main data source in this respect was desk research. The Impact Assessment Study Teams went through grey and academic literature to identify the main challenges in the scientific and technologic fields and in the economic sectors relevant for their candidate partnerships. The review of official documentations, especially from the European Commission, additionally helped understand the main EU policy proprieties that the initiatives under assessment could contribute to achieve.

Almost no candidate institutionalised European Partnership is intended to emerge ex nihilo. Partnerships already existed under Horizon 2020 and will precede those proposed by the European Commission. In the assessment of the problems to address, the Impact Assessment Study Teams therefore considered the achievements of these ongoing partnerships, their challenges and the lessons that should be drawn for the future ones. For that purpose, they reviewed carefully the documents in relation to the preceding partnerships, especially their (midterm) evaluations conducted. The bibliography in Appendix A gives a comprehensive overview of the documents and literature reviewed for the present impact assessment study.

Finally, the description of the context of the candidate institutionalised European Partnerships required a good understanding of the corresponding research and innovation systems and their outputs already measured. The European Commission services and, where needed the ongoing Joint Undertakings or implementation bodies of the partnerships under Article 185 of the TFEU, provided data on the projects that they funded and their participants. These data served as basis for descriptive statistic of the numbers of projects and their respective levels of funding, the type of organisations participating (e.g. universities, RTOs, large enterprises, SMEs, public administrations, NGOs, etc.) and how the funding was distributed across them. Special attention was given to the countries (and groups of countries, such as EU, Associated Countries, EU13 or EU15) and to the industrial sectors, where relevant. The sectoral analysis required enriching the eCORDA data received from the European Commission services with sector information extracted from ORBIS. We used the NACE codification up to level 2. These data enabled identified the main and, where possible, emerging actors in the relevant systems, i.e. the organisations, countries and sectors that will need to be involved (further) in the future partnerships.

The horizontal teams also conducted a Social Network Analysis using the same data. It consisted in mapping the collaboration between the participants in the projects funded under the ongoing European partnerships. This analysis revealed which actors – broken down per type of stakeholders or per industrial sector – collaborate the most often together, and those that are therefore the most central to the relevant research and innovation systems.

The data provided by the European Commission finally served a bibliometric analysis aimed at measuring the outputs (patents and scientific publications) of the currently EU-funded research and innovation projects. A complementary analysis of the Scopus data enabled

to determine the position and excellence of the European Union on the international scene, and identify who its main competitors are, and whether the European research and innovation is leading, following or lagging behind.

All together, these statistical analyses will complement the desk research for a comprehensive definition of the context in which the candidate institutionalised European Partnerships are intended to be implemented. The conclusions drawn on their basis will be confronted to the views of experts and stakeholders collected via three means:

- The comments to the inception impact assessments of the individual candidate institutionalised European partnerships received in August 2019
- The open public consultation organised by the European Commission from September to November 2019
- The interviews (up to 50) conducted by each impact assessment study team conducted between August 2019 and January 2020.

For instance, in all three exercises, the respondents were asked to reflect on the main challenges that the candidate institutionalised European Partnerships should address. In the open public consultations, they mainly reacted to proposals from the European Commission like when they were given to opportunity to give feedback to the inception impact assessment.

The views of stakeholders (and experts) were particularly important for determining the basic functionalities that the future partnerships need to demonstrate to achieve their objectives as well as their most anticipated scientific, economic and technological, and societal impacts. The interviews allowed more flexibility to ask the respondents to reflect about the different types of European Partnerships. Furthermore, as a method for targeted consultation, it was used to get insights from the actors that both the Study Teams and the European Commission were deemed the most relevant. For the comparative assessment of impacts, the Study Teams confronted the outcomes of the different stakeholder consultation exercises to each other with a view of increasing the validity of their conclusions, in line with the principles of triangulation. Appendix B includes also the main outcomes of these three stakeholder consultation exercises.

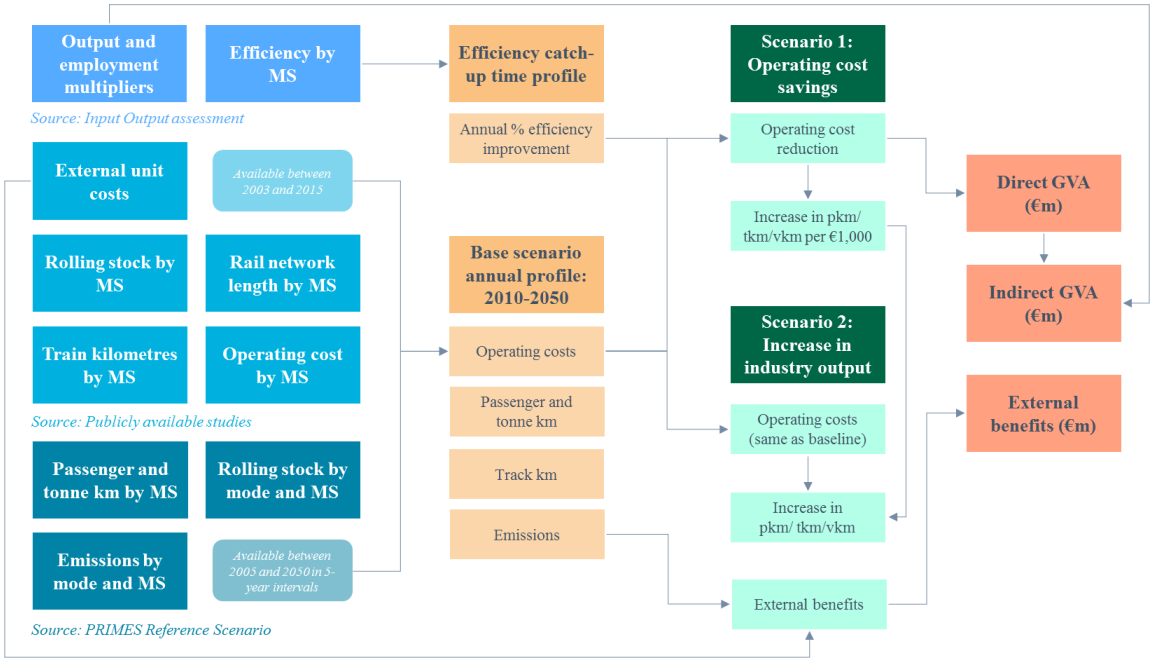
The comparison of different options for European partnerships additionally relied on a cost-effectiveness analysis. When it comes to research and innovation programmes, the identification of costs and benefits should primarily be aimed at identifying the "value for money" of devoting resources from the EU (and Member States) budget to specific initiatives. Based on desk research and consultation with the European Commission services, the horizontal study team produced financial estimates for different types of costs (preparation and setup costs, running costs and winding down costs) and per partnership option. The costs were common to all candidate European Partnerships. The results of the cost model were displayed in a table, where each cost was translated on a scale using "+" in order to ease the comparison between the partnership options.

A scorecard analysis, which allocated each option a score between 1 and 3 against selected variables, was used to highlight those options that stand out as not being dominated by any of the other options in the group: such options are then retained as the preferential ones in the remainder of our analysis. It also allowed for easy visualisation of the pros and cons of alternative options.

C.2 *Overview of the modelling framework developed for the assessment of impacts of the candidate institutionalised partnerships for transforming Europe's rail system*

We have estimated a number of economic/technological impacts using a model developed for a 'Study on the Cost and Contribution of the Rail Sector', undertaken by Steer on behalf of the European Commission in 2015. The design of the model is illustrated in the figure below.

Figure 44: Illustration of the modelling framework



Source: Steer

As shown, the model uses the following inputs:

- An efficiency score for each of the Member States in the base year and a profile of how efficiency changes over time;
- Metrics measuring the scale of the current network (track kilometres), current operations (train kilometres), current fleet (number of vehicles) and operating costs for each Member State, as well as external cost unit rates; and
- Inputs from the PRIMES Reference Scenario, including activity (passenger and tonne kilometres), fleet composition and emissions for all modes and Member States up to 2050.

As originally specified, the model assesses two different scenarios by Member State:

- One where the Member State railway industry becomes more efficient and the gains in efficiency are fully reflected through savings in operating costs passed on to passengers and freight customers; and
- One where the efficiency gains are fully reinvested in the railway industry, which results in increases in passenger and tonne kilometres.

However, it is possible to adapt the model to investigate the effect of different combinations of transport cost savings and investment.

The model has been used to calculate the external impacts of efficiency gains on traffic levels, mode share, employment and environmental emissions. It can also be used to

generate estimates of impact on the economy, measured in terms of Gross Value Added (GVA).

The S2R JU release 2.0 KPI results showing the potential improvement in industry life cycle costs have been used to provide an assumption for the improvement in efficiency under the baseline. The model was then used to estimate the impact of the policy options based on assumptions of further progress towards meeting the KPI target in each case. These assumptions were informed by consideration of both the level of efficiency gains potentially achievable due to R&I activity under each option and the extent of market take-up in each case.

The following table provides an indication of matrix of assumptions used. As described in *Section 6* of the main report, the assumed potential for reductions in life cycle costs were combined with the market take-up value to generate a single value for the assumed efficiency savings to be input into the model.

Table 32: Key efficiency assumptions used in the impact assessment

Option	Potential reduction in life cycle costs by 2030 (assuming 100% market take-up)	Market take-up of R&I outputs	Commentary
Traditional open calls	Passenger: 16.5% reduction Freight: 26% reduction	25 - 33%	Cost reductions indicated by S2RJU KPI release 2.0 (averaged in the case of passenger) – assumed to be captured in baseline. Range of market take-up observed prior to establishment of the S2R JU, as reported by Foster Rail and previous studies.
Co-programmed partnership	Passenger: 25% reduction Freight: 35% reduction	45 - 60%	Assumes some further progress towards targets and a higher rate of market take-up than under the baseline. However, given that several aspects of the problem would persist under the baseline, we have assumed that the improvements are limited.
Article 187 partnership	Passenger: 50% reduction Freight: 50% reduction	50 - 75%	Assumes KPI targets for current JU are met. Market take-up reflects stakeholder views on potential under an institutional partnership.

Source: Steer review of sources identified in the table

The model was used to generate estimates of changes in traffic levels and modal shift against the baseline on the assumption that 50% of efficiency improvements are passed on to rail passengers and freight customers in the form of, respectively, lower fares and lower freight rates, and that 50% are captured in the form of released funds for additional investment. The model outputs are reported in *Section 6.1.2* of the main report.

Appendix D Additional information on the policy context

D.1 Emerging challenges in rail transport

D.1.1 New technologies

The impact assessment undertaken prior to the establishment of the S2R JU highlighted the critical importance of sector modernisation and R&I for the competitiveness of the European rail industry. In recent years the industry has made substantial investments in both infrastructure and rolling stock employing new technology, notably in the form of major extensions of the European high-speed rail network, the development and deployment of ERTMS and the automation of metro systems. A key focus has been the development of integrated rail systems enabling substantial increases in capacity compared to networks operated using conventional technology.

However, the sector also faces challenges from other transport sectors that are transforming travel opportunities through new technologies. These include:

- Electric vehicles, which have the potential to reduce the environmental impact of travel by road and hence to undermine the environmental advantages currently attributed to rail;
- Autonomous vehicles, which enable passengers to make the same use of travel time as they currently make when travelling by train and allow road hauliers to deploy a single driver to control a whole rake of freight vehicles; and
- The mobility as a service (MaaS) concept, whereby the benefits of public and private transport are combined and made available according to when they are needed, such that some of the benefits traditionally ascribed to public transport are potentially reduced.

There is debate about the impact of some of these technologies on rail transport, since some are either transferable to, or have been previously adopted by, the rail sector (for example, driverless trains and virtual coupling) or complementary to the provision of rail services (for example, rail could form part of an integrated MaaS solution). However, as noted in a recent report from the Centre on Regulation in Europe,[56] exploiting the benefits of these and other technologies for the benefit of rail services would require coordination between manufacturers, train operators (who are often contracted by government bodies) and infrastructure managers (who are also typically funded by the public sector). The complex interaction between these stakeholders tends to undermine incentives for R&I and goes some way to explaining the differences in research effort between rail and other sectors.

At the same time, the potential for developing and applying new technologies in the rail sector is substantial, as described in recent position papers published by the European Rail Research Advisory Council (ERRAC)[57]. Future R&I could be expected to deliver substantial improvements in the attractiveness, cost-efficiency and environmental impact of rail services through the application of new technology to almost every element of the rail system. Possible applications identified by ERRAC include the following:

[56] Chris Nash and Andrew Smith (2019), The Future of Rail Regulation and Competition for an Innovative Industry, Centre on Regulation in Europe, February 2019, available at: https://www.cerre.eu/sites/cerre/files/190201_IssuePaper_RailInnovation_Final-compressed.pdf.

[57] 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/.

- New (5G) digital technology can be used to enable the 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 more efficient use of existing networks and potentially reduce the need for costly capacity expansion to accommodate more services.
- 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 repairing itself.
- In the case of rolling stock, new materials and structures are needed to reduce weight and track damage, while innovative sub-systems could improve the passenger experience by reducing noise, allowing smoother braking and acceleration and increasing information on connecting transport services.
- IT solutions based on train to trackside connectivity can improve both passenger and freight services. Passengers can benefit from exchange 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.
- Various technologies are being developed that will enable reduced energy consumption across the whole rail system. In the case of rolling stock, hybrid propulsion systems allowing energy storage will increase the operational range and flexibility of trains while reducing reliance on diesel fuel. SMART grid technology will allow better management of power supplies, improving energy efficiency and reducing environmental impacts.
- ERRAC has noted that the future application of these and other technologies will require a range of low Technology Readiness Level (TRL) research activities, some of which have already been initiated by the existing JU. As their deployment will involve different organisations and different parts of the rail system, realisation of the associated benefits will depend critically on effective collaboration between different stakeholders.

Discussions with stakeholders suggest that ERRAC's view on the future direction of R&I activity is widely shared across the rail industry, with UNIFE, CER and EIM as well as individual manufacturers, train operators and infrastructure managers highlighting similar themes, although different stakeholders emphasise different aspects of the broad research agenda. For example, in a recent position paper UNIFE has highlighted the following key themes.[58]

- The exploitation of Big Data through effective management and processing of data to improve decision-making, for example in system maintenance;
- The need for robust cybersecurity measures to address the growing risk of cyber-attacks;
- The application of artificial intelligence in areas such as train operations and autonomous driving as well as mechanisation of infrastructure construction, renewals and maintenance;

[58] UNIFE (2019), UNIFE Vision Paper on Digitalisation – Digital Trends in the Rail Sector, April 2019, available at: http://unife.org/component/attachments/attachments.html?id=1011.

- The use of digital technology in supporting new, seamless mobility services (including rail as the backbone of an integrated transport system); and
- The digitalisation of freight logistics services to provide benefits such as end-to-end logistics planning and sharing of information.

Similarly, UITP has identified six areas of R&I of particular relevance to urban rail operators.[59] The participation of such operators in the activity coordinated by the S2R JU has so far been limited and there is general recognition among stakeholders of the need to collaborate with them more effectively under Horizon Europe, not least because of the potential to use new technology to better integrate national rail networks with urban transport systems and respond more effectively to the transport needs of urban populations (discussed further below). Hence, the correspondence between the research priorities of urban operators, as articulated by UITP, and those of other rail industry stakeholders are an important consideration in determining the direction of rail-related R&I. In practice, the themes highlighted by UITP chime with the priorities advocated by ERRAC, UNIFE and the JU itself. Nevertheless, in discussions UITP has emphasised the importance of ensuring that specific projects sponsored under Horizon Europe are relevant to urban operators.

D.1.2 Improving the competitiveness of the rail sector

The attractiveness of rail services to both passengers and freight customers varies considerably across Europe, with substantial differences in service quality observed both within and between Member States. Moreover, overall levels of satisfaction suggest that inadequate service quality continues to discourage greater use of the European rail network. For example, the latest Eurobarometer survey of satisfaction with European rail services, undertaken in 2018,[60] indicates that:

- Only 66% of passengers were satisfied with the frequency of trains (although this represents a significant increase on satisfaction levels at the time of the previous survey in 2013);
- Only 59% of passengers were satisfied with the punctuality and reliability of rail travel;
- Satisfaction with complaint handling mechanisms was particularly low, with only 38% of passengers stating that such mechanisms are simple and accessible; and
- High levels of satisfaction with information on timetables and platforms (92%) and ticket buying facilities (92%) were balanced by poor satisfaction with accessibility of stations and platforms (53%) and staff assistance for persons with special needs (41%).

Survey respondents cited a range of reasons for not travelling by rail, including difficulties getting to the station, inaccessibility of platforms and lack of pre-journey information.

There is no comparable survey of satisfaction with freight services, but the European Commission has synthesised the evidence available from positions papers, responses to public consultations and contributions to conferences and workshops. The key concerns raised by shippers and other stakeholders and identified in the Commission's sixth report on monitoring the development of the rail market include:

[59] UITP (2018), Urban Rail Research Priorities – Urban Operator Needs, Exploratory Report, September 2019

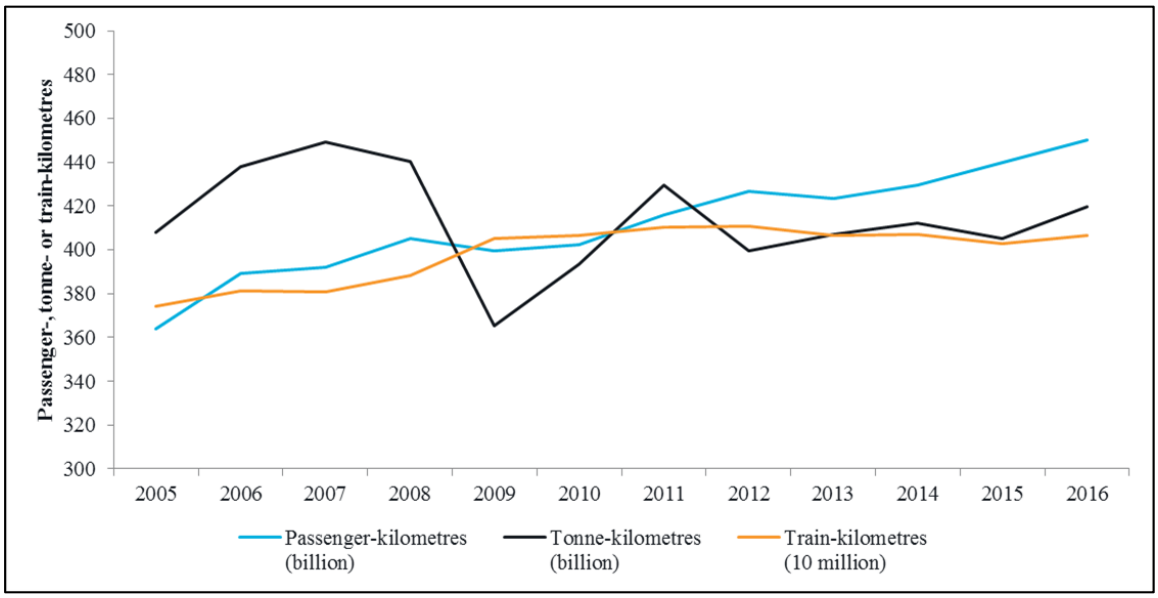
[60] European Commission (2018), Flash Eurobarometer 463: Europeans' satisfaction with passenger rail services, available at: https://data.europa.eu/euodp/en/data/dataset/S2172__ENG.

- Poor service reliability as compared with road transport (the main competitor to rail services in freight markets), driven in part by insufficient interoperability (highlighted by the Rastatt incident);[61]
- Inadequate provision of tracking and tracing information, such that shippers cannot reliably estimate arrival times;
- A lack of flexibility in the operation and management of freight traffic, together with related concerns about the lead time needed to launch new rail freight services; and
- The cost of services in specific market segments, particularly where freight volumes and transport distances are low.

The Commission has concluded that satisfaction with European rail freight services is mixed while noting that a more systematic approach to the measurement of satisfaction is needed.

The need to improve the attractiveness, and hence the competitiveness, of the rail sector in Europe is demonstrated by recent trends in rail traffic, as illustrated in *Figure 45*.

Figure 45: Trends in rail traffic 2006 – 2016

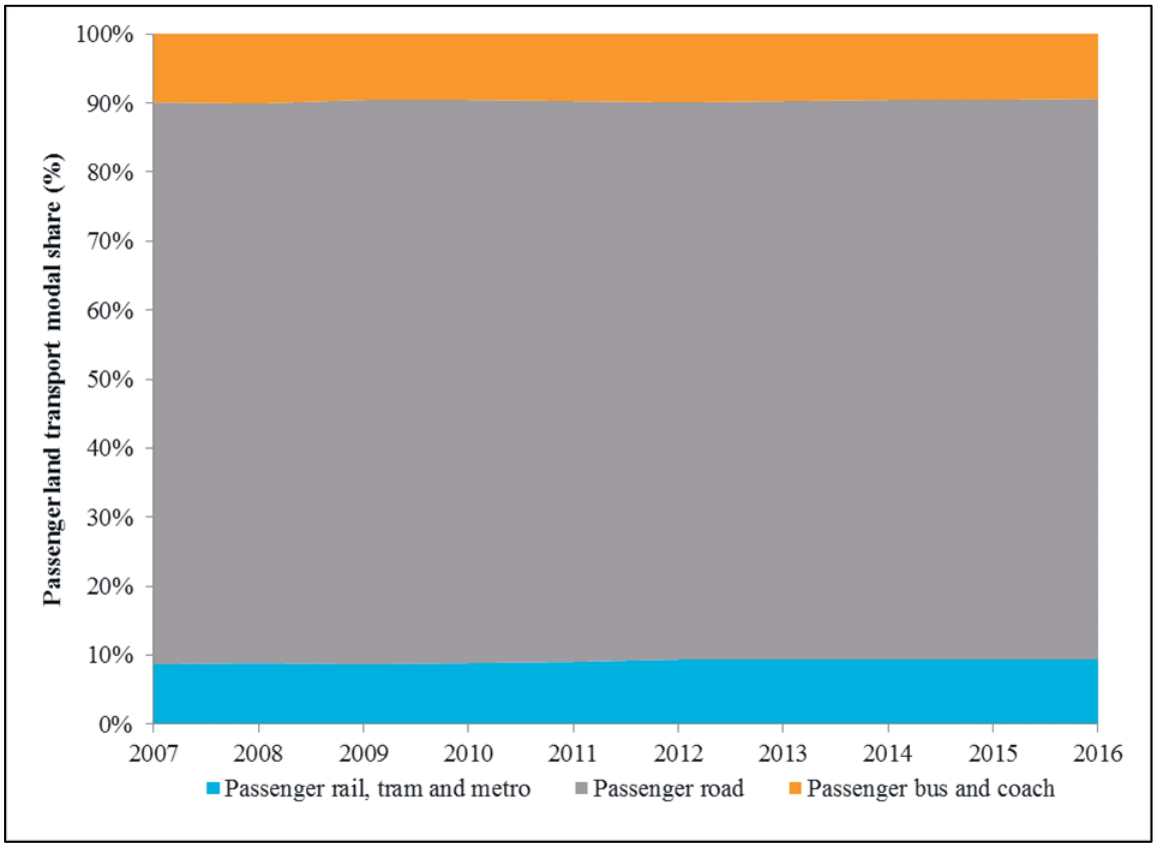


Source: European Commission (2019), Sixth Rail Market Monitoring Survey, Figure 16

In the case of passenger traffic, while growth has been steady and was interrupted only briefly by the 2009 economic recession, it has nevertheless been limited. Compound annual growth over the period shown amounted to only 1.9%. Freight traffic, which was severely affected by the recession, grew by less than 0.3% per annum. This growth has been insufficient to challenge the dominance of road in both passenger and freight transport markets, and rail's market share has remained broadly static over many years, as shown in Figure 46 and Figure 47.

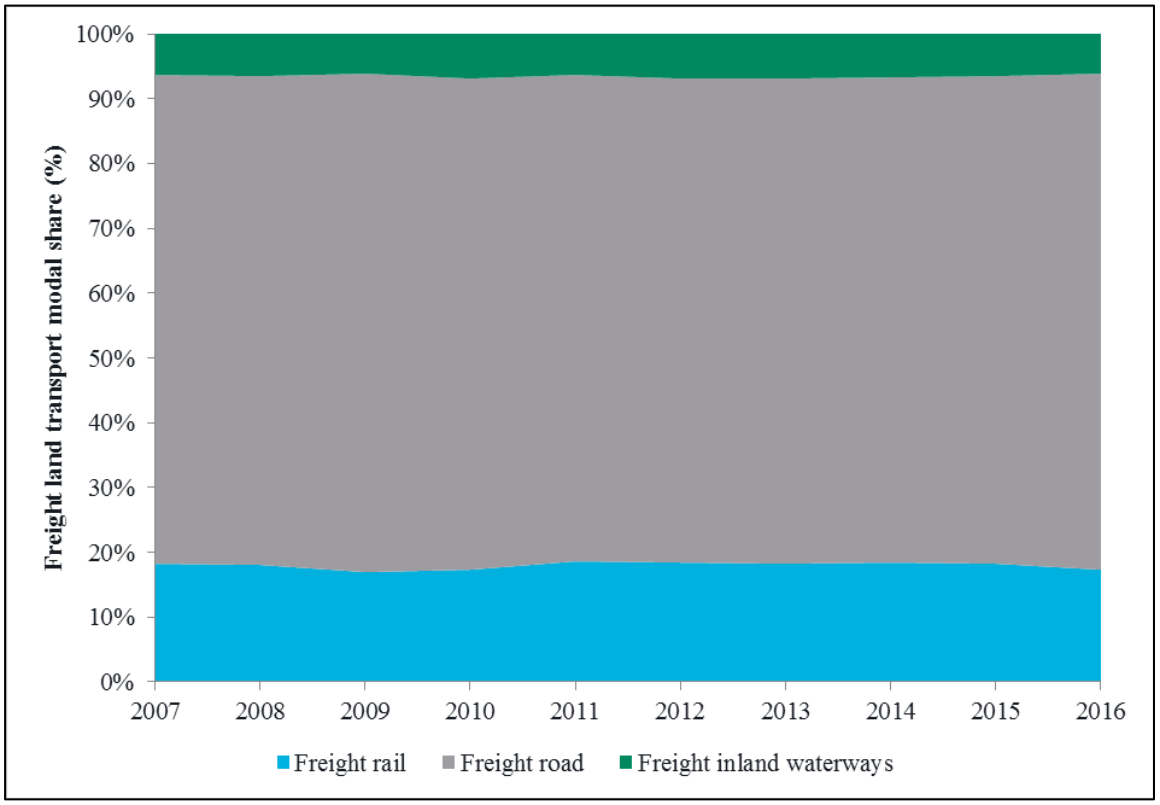
[61] In August 2017 a major incident that occurred during engineering works led to a full closure of the Rhine valley line, one of the busiest rail freight corridors in Europe, for seven weeks. The impact of the incident was compounded by a lack of interoperability along routes in other Member States, which limited the availability of diversionary capacity.

Figure 46: Rail modal share of passenger traffic 2006 – 2016



Source: European Commission (2019), Sixth Rail Market Monitoring Survey, Figure 19

Figure 47: Rail modal share of freight traffic 2006 – 2016



Source: European Commission (2019), Sixth Rail Market Monitoring Survey, Figure 27

In the case of passenger traffic, heavy rail, tram and metro services have failed to secure 10% of the market at any point in the last ten years, although the share of heavy rail alone did increase from 6.8% to 7.6%. Rail's share of freight traffic remained at just above 18% for most of the period and even declined to 17.4% in 2016. Overall, rail's competitive position relative to other modes has not changed materially, notwithstanding substantial progress in market opening and more competition as a result of the various packages of EU rail legislation and other R&I initiatives under previous Framework Programmes. Improving its competitiveness will depend in part on progressing R&I programmes that can help to address the issues affecting perceptions of service quality among both passengers and freight customers.

D.1.3 Responding to key social trends

The future direction of rail-related R&I must also be considered in the context of established and emerging social trends affecting the provision of transport services. An important trend observed across the world that raises major challenges for Europe's transport systems is the process of urbanisation. The share of Europe's population living in urban and suburban areas is projected to reach 75% in 2020 and 84% by 2050.[62] This can be expected to exacerbate a range of problems that cities across Europe are already facing, including traffic congestion, excessive noise and poor air quality, threats to health and social inclusion and restricted space for living and broader economic development.

The trend towards urbanisation is also linked to changes in travel patterns and the requirements of users of transport services. Passengers are becoming ever more demanding when travelling around cities, for example seeking services that are more tailored to their needs and available on demand rather than only at pre-scheduled times. They also expect more detailed, real time information on travel options and door-to-door journey solutions based on the integration of different modes and minimisation of interchange times. At the same time, freight customers are demanding shorter delivery times and more efficient 'last mile' operations as well as information that allows them to track the progress of deliveries in real time.

The ability of urban transport systems to meet these demands will depend on the effective exploitation of many of the technologies previously discussed. In particular:

- Digital technology and effective management of Big Data could allow transport operators to identify individual travel behaviour and offer tailor-made journey solutions that take account of any disruption to services.
- The digitalisation of payment systems could enable more dynamic pricing of transport services, helping to encourage shifts in travel behaviour that relieve congestion and improve the efficiency of scheduled urban services.
- The further development of the MaaS concept could provide for the full integration of bike-, car- and ride-sharing with rail services to make the most efficient use of all the urban transport capacity available.
- The further application of digital technology could support the development of multi-modal traffic management systems, allowing urban transport authorities to offer a substantially improved service across their respective areas, benefitting both residents and visitors.

UNIFE has noted that the S2R JU's existing R&I agenda, in particular Innovation Programme 4 (see further below) is already supporting the realisation of these and other

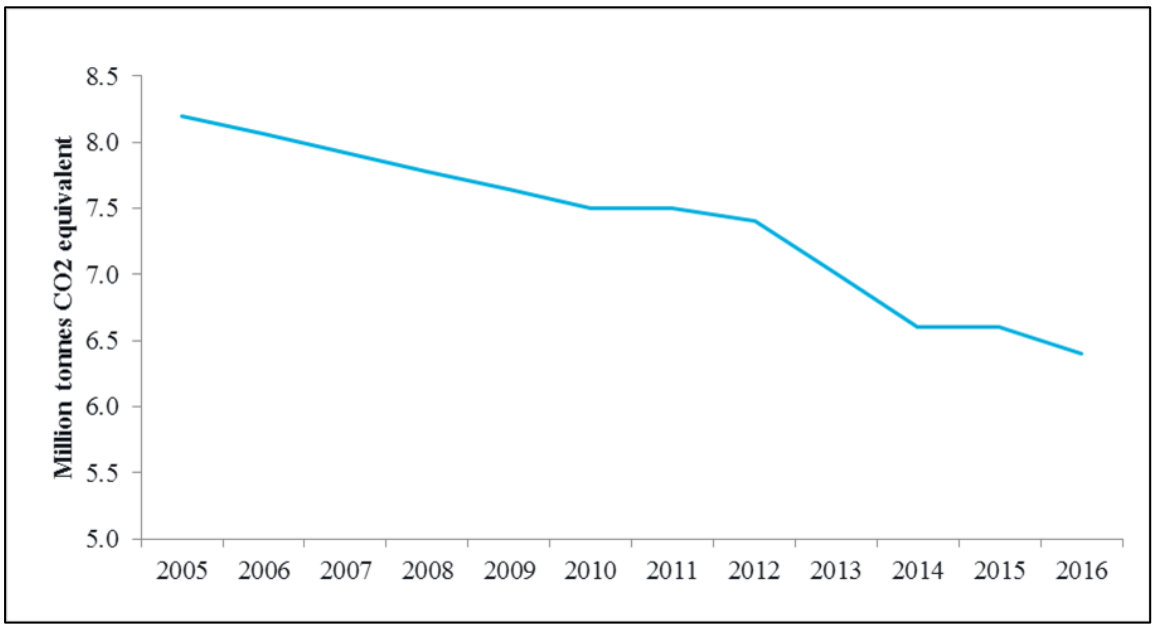
[62] See United Nations Population Division, World Urbanisation Prospects 2018, available at: https://population.un.org/wup/Download/.

initiatives, and that further activity should be progressed under Horizon Europe. However, if future R&I programmes are to address the issues raised by urbanisation effectively, urban operators must have greater involvement in their scope and specification than has been the case in the past.

D.1.4 Reducing the environmental impact of transport

The need to strengthen rail's ability to compete effectively with other modes has been a key objective of EU transport policy at least since the 2011 Transport White Paper (discussed further below) and was reaffirmed in the Commission's recently published strategic long-term vision. This policy focus has been driven partly by the need to reduce the environmental impacts of all aspects of economic growth, including increasing transport demand, and the recognition that rail is generally more environmentally friendly than other modes.

Figure 48: European rail greenhouse gas emissions 2005 - 2016



Source: European Commission (2018), Statistical Pocketbook, page 134[63]

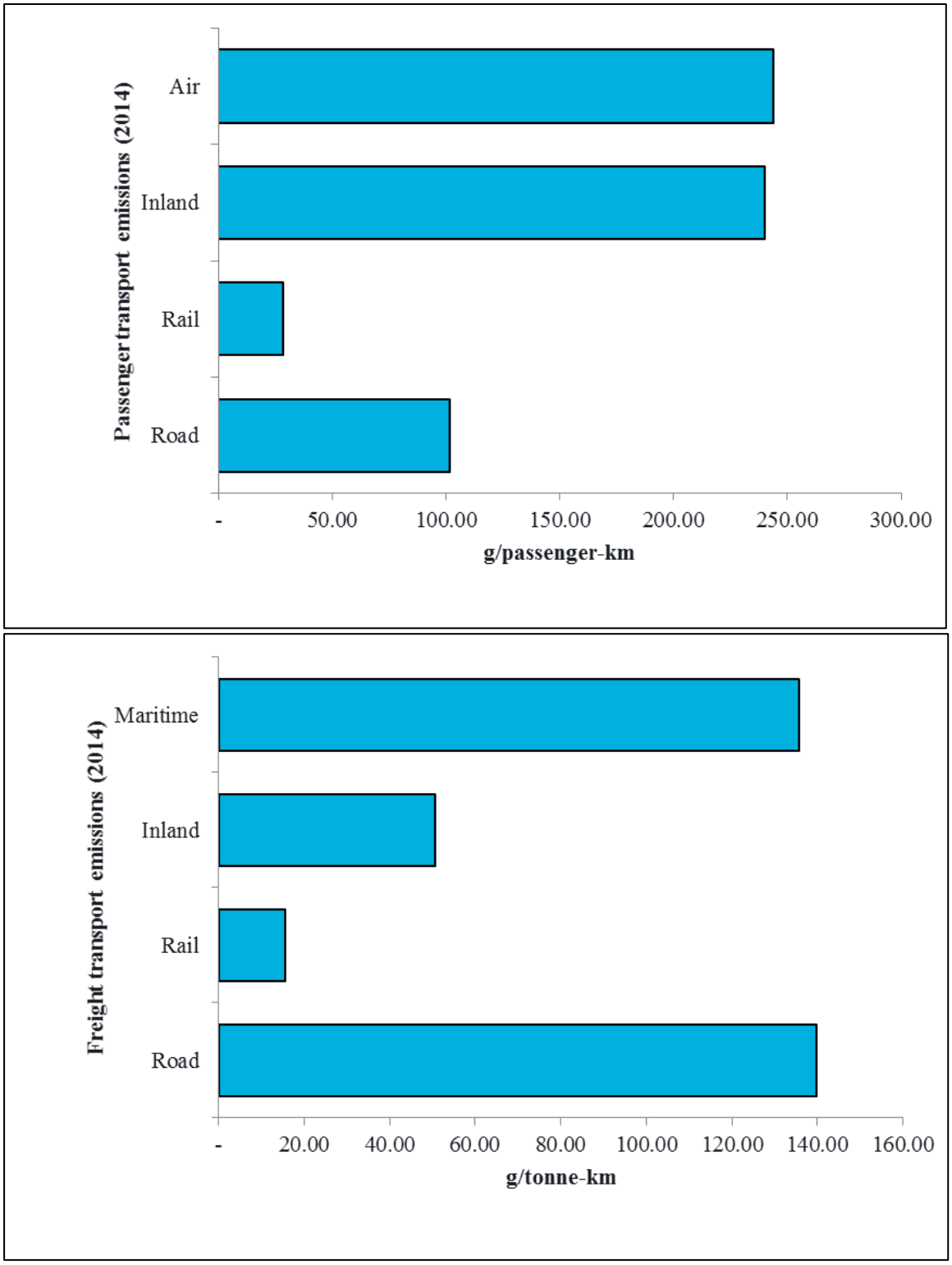
As shown in *Figure 48*, the European rail sector has been relatively successful in driving down the overall level of greenhouse gas emissions that it generates, and the wider rail industry continues to work towards further reductions. The UIC, a professional body representing the global industry, recently announced that 28 of its European members had committed to reducing CO_2 emissions per passenger-km and per tonne-km by 50% by 2030,[64] and much of the research effort directed by the S2R JU is expected to have significant environmental benefits. The achievements to date have been heavily driven by increased electrification of rail networks, combined with efforts by the power industry to reduce reliance on fossil fuels. However, the rail industry itself has made a significant contribution to greater energy efficiency through the introduction of lighter rolling stock using more efficient traction and the application of technologies such as regenerative braking (which returns energy produced in braking to the power system) and energy metering (which, inter alia, allows train operators to instruct drivers in more energy efficient driving techniques).

[63] Statistical Pocketbook 2018: EU transport in figures, available at: https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2018_en.

[64] See https://uic.org/sustainable-development/energy-and-co2-emissions/.

This progress has meant that rail continues to produce fewer greenhouse gas emissions per passenger-km and per tonne-km than aviation and road transport, as shown in *Figure 49*, although rail's advantage depends critically on the load factors achieved by train operators. This underlines the importance of improving the competitive position of rail services in urban, intercity and inter-regional transport markets.

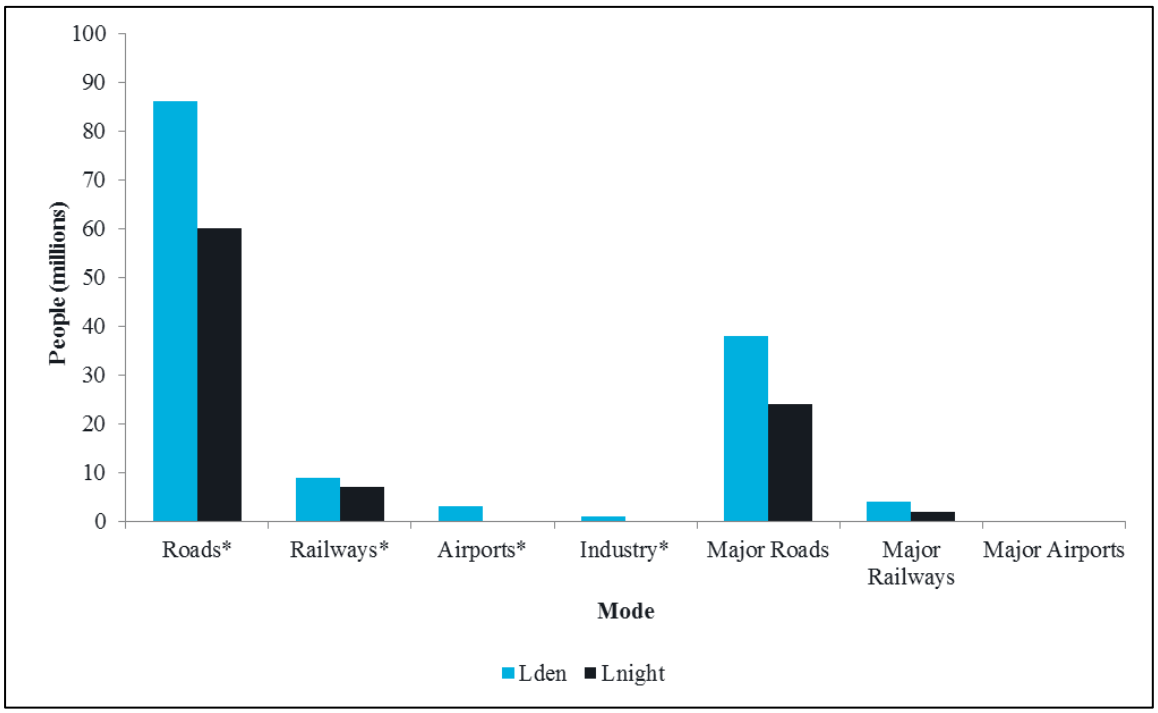
Figure 49: Specific CO_2 emissions by passenger and freight transport mode



Source: European Environment Agency[65]

Rail can also contribute to the reduction of other environmental impacts such as noise and vibration, for example by reducing road traffic and by routing passenger and freight flows along dedicated networks located away from centres of population. Nevertheless, after road transport, rail is a significant contributor to noise pollution across Europe, as shown in *Figure 50,*[66] with substantial numbers of people exposed to noise levels in excess of the indicators established by the Environmental Noise Directive (55dB during the day and 50dB at night).[67]

Figure 50: Number of people affected by noise pollution from different transport modes



Source: European Environmental Agency Noise Observation and Information Service for Europe

In its Staff Working Document accompanying the sixth report on monitoring the development of the rail market,[68] the Commission notes that various initiatives have already been adopted to reduce noise exposure due to rail transport, including a TSI on noise, financial assistance under CEF and noise-differentiated track access charges, but that progress has nevertheless been relatively slow. While some reduction can be achieved through retrofitting freight wagons with composite brake blocks, further improvements are likely to require additional R&I.

D.2 Overview of European transport policy

D.2.1 The 2011 Transport White Paper

In 2011, the Commission published a 'Roadmap to a Single European Transport Area – towards a competitive and resource efficient transport system' (the Transport White

[65] See https://www.eea.europa.eu/data-and-maps/indicators/energy-efficiency-and-specific-co2-emissions/energy-efficiency-and-specific-co2-9.

[66] European Environmental Agency Noise Observation and Information Service for Europe, available at: https://www.eea.europa.eu/data-and-maps/data/external/noise-observation-and-information-service.

[67] Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise

[68] See footnote 78.

Paper),[69] which set out a series of plans and associated targets for improving the competitiveness, efficiency and sustainability of European transport, removing barriers and bottlenecks in transport infrastructure and addressing societal challenges linked to increasing mobility and connectivity. It described a vision for the European transport network, broadly defined, which included several rail-related goals, in particular:

- A shift of 30% of road freight travelling over 300 km to rail or waterborne transport by 2030, and a shift of more than 50% by 2050, enabled through efficient rail freight corridors and further infrastructure development;
- Completion of the European high-speed rail network by 2050, with most medium-distance passenger transport moving by rail by the same date;
- The delivery of a fully functional, Union-wide and multimodal TEN-T core network by 2030 (with further quality and capacity enhancements completed by 2050);
- Connection of all core airports to rail (preferably high-speed rail) services and connection of all core seaports to rail freight networks by 2050; and
- Deployment of the European Rail Traffic Management System (ERTMS) (among other comparable transport management systems) in accordance with the associated deployment plan.

These goals have set the framework for EU rail policy during the period of Horizon 2020 and have been echoed in the objectives for both the S2R JU and the proposed new partnership for Transforming Europe's Rail System. The goals are critically dependent on the uptake of technological innovation that can help to deliver a fully integrated railway system for Europe and ensure a step-change in the attractiveness of rail services from the perspective of both passengers and freight customers.

At the same time, while clearly still important in guiding rail policy, the Transport White Paper was published some eight years ago and inevitably reflected the priorities perceived by policy makers at the time. Moreover, some of the goals have been challenged, notably in the interim evaluation of the S2R JU completed in 2017.[70] In commenting on the JU's objectives, the interim evaluation report notes that the White Paper calls for a tripling of the length of the current high-speed rail network and questions whether this is realistic. It also observes that there is wide variation in the utilisation of rail networks across Europe, and that blanket objectives to increase capacity may be inappropriate. Discussions with stakeholders for this study have tended to confirm that there should be greater emphasis on increasing the capacity of the existing Network under Horizon Europe.

D.2.2 Transport's contribution to environmental objectives

A key overarching objective of Union transport policy, addressing climate change through a reduction in carbon emissions from transport, is clearly restated in a recent Commission Communication, 'A Clean Planet for all – A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy', published in November 2018.[71] The vision describes various pathways "to a net-zero greenhouse gas emissions economy" based on seven building blocks including embracing "clean, safe and connected

[69] European Commission (2011), Roadmap to a Single European Transport Area – towards a competitive and resource efficient transport system, 28 March 2011, available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0144&from=EN.

[70] Eric Fontanel, Roderick Smith, Heather Allen, Michael Dooms (2017), Interim Evaluation of Shift2Rail Joint Undertaking (2014-2016), June 2017, available at: https://ec.europa.eu/research/evaluations/pdf/s2r.pdf.

[71] Legislative texts, together with further information on the Fourth Railway Package is available at: https://ec.europa.eu/transport/modes/rail/packages/2013_en.

mobility". While noting that transport is responsible for a quarter of greenhouse gas emissions in the European Union, the Commission argues that a strategy for reducing such emissions cannot rely exclusively on the electrification of transport modes using renewable energy. Rather, it will require action to encourage modal shift to rail and other more environmentally friendly modes, not only by completing existing programmes such as TEN-T and the deployment of ERTMS but, more generally, by fostering innovation and greater efficiency.

Accordingly, the vision calls for a major coordinated R&I effort "built around a coherent strategic research and innovation and investment agenda" to "make low and zero-carbon solutions economically viable and bring about new solutions not yet mature or even known to the market". The emphasis on coordination and the development of a coherent strategy underlines the importance of a range of organisations, in the rail industry as elsewhere, working in close collaboration to achieve common societal goals. Again, it echoes the aim of the proposed partnership, as previously described, to increase the competitiveness of the rail sector through coordinated investment in technologies that enable innovation and enhance the attractiveness of rail services to both passengers and freight customers.

D.2.3 The Fourth Railway Package

The proposal for a new partnership must also been seen in the context of recent rail industry reforms, notably the Fourth Railway Package, which completes the legal framework governing a process of industry restructuring, harmonisation and market opening that began some 30 years ago with Directive 91/440/EEC on the development of the Community's railways. The Fourth Railway Package is a set of six legislative texts[72] designed to implement the final elements of the Single European Railway Area (SERA) with a view to revitalising the sector and making it more competitive relative to other transport modes. It is comprised of two pillars:

- A technical pillar focusing on a more streamlined, pan-European approach to safety certification and vehicle authorisation, measures to improve interoperability across different national rail networks and an enhanced role for the European Union Agency for Railways (ERA); and
- A market pillar, strengthening previous legislation designed to separate infrastructure management and train operation, providing a more level playing field for rail market access and for greater competitive tendering of public service contracts for rail services.

The implementation of a coordinated R&I effort under Horizon Europe will be complementary to the completion of SERA, since it can be expected to generate opportunities for innovation that can be exploited more effectively in a dynamic rail market environment. At the same time, it will provide a platform for collaboration between different industry players now subject to a greater degree of organisational separation than was previously the case.

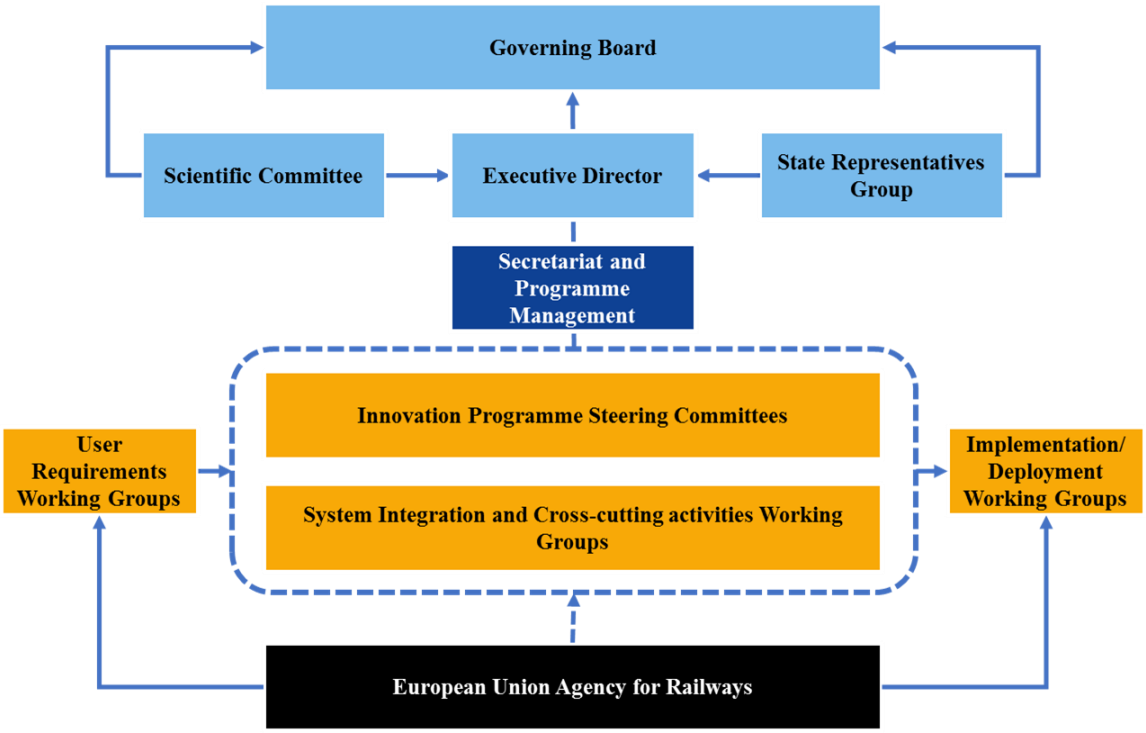
D.3 The Shift2Rail Joint Undertaking

D.3.1 Organisation and governance

The organisation and governance of the S2R JU are illustrated in the figure below.

[72] Legislative texts, together with further information on the Fourth Railway Package is available at: https://ec.europa.eu/transport/modes/rail/packages/2013_en

Figure 51: Organisation and governance of the S2R JU



Source: Eric Fontanel, Roderick Smith, Heather Allen, Michael Dooms (2017), Figure 5

As shown, the organisation comprises:

- A Governing Board, including representatives of the founding members, associate members and observers (from ERA and the States Representative Group);
- An Executive Director, supported by a secretariat and programme management department, responsible for oversight of the work programme and day-to-day management of the organisation;
- A series of Steering Committees overseeing each of the five Innovation Programmes (IPs) described below;
- A Scientific Committee and a States Representative Group, providing advice to both the Executive Director and the Governing Board; and
- Various Working Groups considering user requirements, implementation of the outputs of the R&I activity and integration across the IPs as well as various cross-cutting themes.

D.3.2 Innovation programme funding

The R&I activity coordinated by the JU is organised according to a number of innovation programmes (IPs). The table below sets out the budget allocation across IPs expected following adoption of the Annual Work Plan for 2020, as provided to us by the JU. At the time of writing this had not yet been formally approved.

Table 33: S2R JU Innovation Programmes and Cross Cutting Activities

Innovation Programmes/activity	Areas of activity
IP1 – cost-efficient and reliable trains, including high capacity and high-speed trains Budget: €212 M	Train interiors Doors and intelligent access systems Traction Train control and monitoring system Lighter car body shell Running gear Brakes
IP2 – advanced traffic management and control systems Budget: €197 M	Smart, fail-safe communication and positioning systems Traffic management evolution Automation Moving blocks and train integrity Smart procurement and testing Virtual coupling Cyber security
IP3 – cost-efficient, sustainable and reliable high-capacity infrastructure Budget: €153 M	New directions in switch and crossing Innovative track design and materials Cost-effective tunnel and bridge solutions Intelligent system maintenance Improved station concepts Energy efficiency
IP4 – IT solutions for attractive railway services Budget: €75 M	Technical framework Customer experience applications Multi-modal travel services
IP5 – Technologies for sustainable attractive European freight Budget: €87 M	Implementation strategies and business analytics Freight electrification, brakes and telematics Access and operation Wagon design Novel terminals, hubs, marshalling yards and sidings New freight propulsion concepts Sustainable rail transport of dangerous goods Long term vision for an autonomous rail freight system

Innovation Programmes/activity	Areas of activity
IPX – Disruptive concepts and technologies and system architecture Budget: €20 M	Development of a functional system architecture for the next generation of railway systems
Cross cutting activities	
Total budget: €31 M	Long-term needs and socio-economic research
	Smart materials and processes
	System integration, safety and interoperability
	Energy and sustainability
	Human capital

Contribution to administrative costs	
Budget share: €13.5	European Union
Budget share: €13.5	Industry

Source: S2R JU

D.3.3 Contribution to rail sector development

As discussed in *Section 1.2.2*, the Council Regulation establishing the JU requires it to meet several objectives that, inter alia, align its activities with the aims of Horizon 2020 and the completion of SERA. The Regulation also sets out key performance indicators (KPIs) that provide a means of measuring its impact on the European rail transport industry. More specifically, the JU is required "to develop, integrate, demonstrate and validate innovative technologies and solutions" that can be measured against the following five KPIs:

- A 50% reduction in the life-cycle costs of the rail system through greater efficiency in the provision of both infrastructure and rolling stock as well as greater energy efficiency;
- A 100% increase in the capacity of the system with a view to accommodating increased demand for both passenger and freight services;
- A 50% increase in the reliability and punctuality of rail services (expressed as a 50% reduction in the percentage of cancellations and late arrivals);
- Removal of the remaining obstacles to interoperability, particularly by closing outstanding open points in the Technical Specifications for Interoperability (TSIs) through the identification of appropriate technological solutions; and

- A reduction in noise, vibration, emissions and other environmental impacts arising from rail transport.

In response, the JU commissioned a KPI measurement framework to help assess the contribution of its R&I activity to the target KPI values set out above. This is designed to capture the impact of the various IPs and underlying technology demonstration programmes on service punctuality/reliability, rail system life cycle cost and capacity by comparing estimated values in 2030 (on the assumption of widespread market take-up of R&I outputs) with values in 2013. The results for release 2.0 of the framework are shown in *Table 34*. Note that these may be modified in further releases.

Table 34: S2R JU KPIs – release 2.0

		Estimated change in 2030 compared with 2013		
		Whole system life cycle costs	**Capacity**	**Punctuality**
Target value		-50%	+100%	+50%
Rail sector	**High speed**	-15%	69%	29%
	Regional	-19%	57%	51%
	Urban	-15%	23%	N/A[73]
	Freight	-26%	134%	78%

Source: S2R JU

To date, the S2R JU appears to be making a strong contribution to the development of a more competitive rail transport industry, with its Annual Activity Report for 2018 highlighting significant progress across a range of activities covered by IP1, IP3 and IP4.[74] In the case of IP2, which focuses on, inter alia, virtual coupling, moving block and automatic train operation, the report noted that some of the technologies are not expected to meet 'demonstrator' level by the end of the current programme, but that concentration of effort in specific areas could be expected to accelerate progress towards this milestone. Similarly, a reorganisation of IP5, which focuses on technologies relevant to the rail freight industry, coupled with the strengthening of links between IP2 and IP5, was expected to help achieve key programme goals.

In discussions held during the stakeholder consultation, the JU has provided further examples of the impact of its IPs on the market. For example, in collaboration with industry organisations such as CAF and Wabtec Corporation, it has developed competitive automatic coupling solutions to be demonstrated on Trafikverket freight trains in September 2020. It is also seeking the support of its members in preparing a business case for the deployment of the technology, which will require funding of €6 billion over six years with an indicative

[73] The punctuality metric within the KPI framework is not considered appropriate for metro services. Modifications of the metric are being considered for release 2.0.

[74] Shift2Rail (2019), Annual Activity Report 2018, June 2019, available at: https://shift2rail.org/wp-content/uploads/2019/07/S2R-JU-Annual-Activity-Report-2018.pdf.

payback of seven years. This is expected to have a significant impact on the market for freight wagons and on the efficiency of European rail freight services.

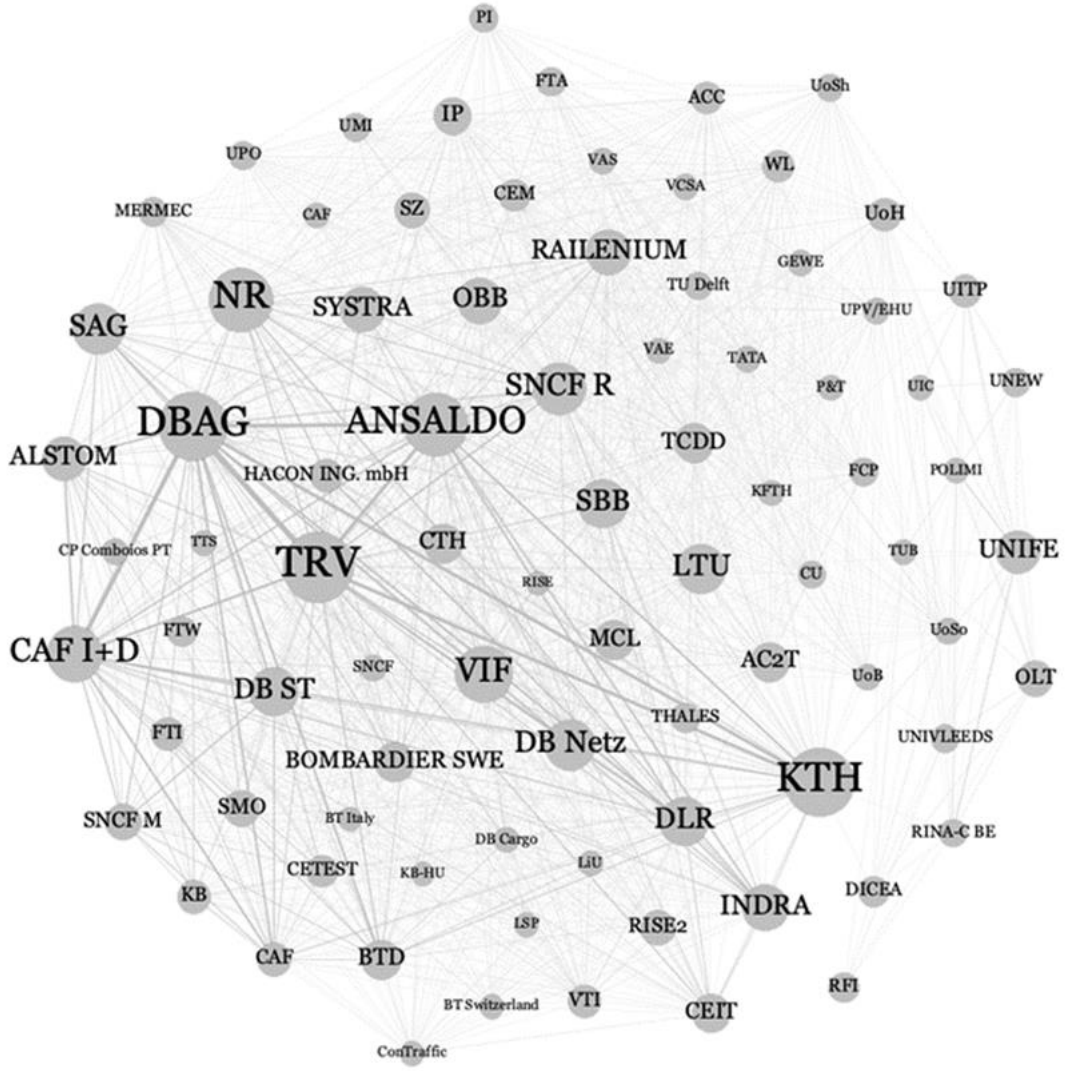
If the JU remains in place, it will be expected to align future R&I with the evolution of the regulatory framework for the rail sector. This will include identifying outputs needed to support the revision of TSIs in 2022 and beyond.

D.3.4 Stakeholder analysis

A key objective for the S2R JU defined in Council Regulation 642/2104 is active promotion of the participation and close involvement of all relevant stakeholders, both from the full rail value chain and from outside the traditional rail industry, in rail-related R&I. Figure 52 shows the results of an analysis of the participation rates of organisations involved in S2R JU projects, based on a preliminary mapping of the network, presented in the form of a network diagram illustrating the level of participation of individual organisations (represented by the size of the circles) and the strength of the connections between them. Note that this mapping of the partnership network is based on an identification of the participants in the partnership projects, derived from ORBIS.

In view of apparent limitations of the NACE codes used to indicate the sectors in which individual organisations are located, we have not represented the allocation of organisations across different sectors in the diagram. However, from a review of the list of participants, we have been able to form a view of the range of sectors covered, distinguishing between categories such as rail infrastructure managers, rail operators, organisations in the RSI, research institutions and universities.

Figure 52: Participation of organisations in S2R JU by NACE industry sector



Source: Technopolis analysis based on Corda and NACE codes

Previous evaluation of the JU

An Interim Evaluation Report on the S2R JU,[75] published in 2017 when the JU had only recently been established, concluded that the scope of activity identified by its Master Plan was still relevant. It also concluded that the JU had already achieved positive effects by bringing many organisations together to work towards common goals, thereby overcoming industry fragmentation and ensuring greater continuity of research objectives. The report noted widespread support for the JU across the industry, particularly in view of its role in enabling large-scale demonstration projects. Overall, it was judged to be well-placed to achieve the level of trust and partnership characteristic of other transport JUs, providing a catalyst for new ideas and new relationships.

At the same time, the evaluation found that there was potential for greater collaboration between the S2R JU and its peers, which faced many of the same challenges and could transfer learning in areas such as SME and Member State participation. It also identified several areas in which the S2R JU could improve, which could similarly inform the structure,

[75] Eric Fontanel, Roderick Smith, Heather Allen, Michael Dooms (2017), Interim Evaluation of Shift2Rail Joint Undertaking (2014-2016), June 2017, available at: https://ec.europa.eu/research/evaluations/pdf/s2r.pdf.

management and activity of any future partnership established under Horizon Europe. The principal shortcomings of the current partnership indicated in the report were as follows:

- Management and communication: the management structure and processes were considered too rigid with, for example, communication between the IPs being limited.
- Openness: as already noted, the evaluation highlighted a need for greater collaboration between the transport JUs. In addition, it indicated that the inability of associate members to apply for open calls unduly limited their participation in key research activity.
- Governance: the evaluation report concluded that Scientific Committee was under-utilised and that the Governing Board should have a more strategic role. It also recommended that the relative roles of the S2R JU and the European Rail Research Advisory Council (ERRAC), a pre-existing body set up to drive rail innovation and knowledge transfer, should be clarified.
- Focus of research effort: the JU was seen to focus on technical rather than societal or operational aspects of the rail sector. The evaluation concluded that a more balanced research agenda, taking more account of the needs of multi-modal and freight transport, was needed.
- Membership: the evaluation suggested a wider coverage of rail sector stakeholders and that the membership composition should be more representative of the rail system as a whole. There was a particular need to increase representation among train operators and urban, as distinct from intercity, rail systems.

Since the interim evaluation was completed, the S2R JU has sought to address its findings through a range of documented actions, for example enhanced engagement with other JUs, measures to reduce the administrative burden of calls for members and a review of the mandate of the Scientific Committee.[76]

[76] S2R JU (2018), Action Plan in response to the recommendations of the interim evaluation of the Shift2Rail JU, March 2018, available at: https://shift2rail.org/wp-content/uploads/2018/07/Decision-08_2018-Annex_Interim_Action_Plan.pdf.

Appendix E Additional information related to the problem definition

E.1 Taxonomy of failures requiring policy intervention

In defining the problem described in *Section 2* of the main report, we have considered failures identified through the application of a standard taxonomy developed by Technopolis. A generic description of the failures appears in *Table 35* and the findings from its application to rail-related R&I are shown in *Table 36*.

Table 35: Standard taxonomy of failures

Market failures	
Market power	Inadequate market structures due to the degree of competition and barriers to entry such as strongly concentrated / closed industry sectors or markets
Externalities	Low return on investments due to difficulties, for innovators, appropriating the outcomes of their investments and limiting undesired spillovers to the benefit of competitors. Those externalities often cause low (private) investments, especially for uncertain and risky R&D activities.
Information asymmetry	Actors within a particular market (or system) have uneven access to information. Some may lack the information they need to develop and exploit their innovative products/services.
Systemic failures	
Capability	Factors related to the individuals' and organisations' absence or shortage of the necessary capabilities to acquire and absorb new knowledge, to adapt to new and changing circumstances, to grasp (technological) opportunities, and to switch from old to new (technological) trajectories. At a systemic level, it relates to 'sufficient scale' or 'critical mass'
Network	Interactions between a set of actors are too dense to allow for novel insights or inspirations to emerge. Strong dependence on few partners may lead to lock-in phenomena. *Weak network failure:* Too limited exchange and collaboration between organisations and individuals, which limit co-creation and co-development of new products and services,
Institutional	Norms and rules (regulatory framework) hinder innovation; social norms and values, and culture hinder innovation
Infrastructural	Lack of the physical (R&D facilities, ICT infrastructure, transport etc.) and knowledge (knowledge, skills, database etc.) infrastructures needed to enable and stimulate innovation activities.

Transformational failures	
Directionality	Lack of shared vision regarding the goal and direction of the required system transformation process. No coordination between the actors involved in system transformation. Absence of targeted funding for R&I activities and infrastructures, which would define collectively accepted trajectories of development.
Demand articulation	A deficit in anticipating and learning about user needs and constraints. Insufficient use of public demand to orient and leverage wider demand and influence innovation activities. Lack of mechanisms to articulate the demand from various groups of actors.
Policy coordination	Missing or weak coherence between the activities of national, regional, sectoral and technological institutions: lack of coordination between innovation and sectoral policies; lack of coordination between ministries and implementing agencies; no alignment between public and private organisations; mismatches in the timing of policy intervention
Reflexivity	Insufficient ability to monitor progress of (transformative) policy interventions towards the achievement of their objectives, to develop adaptation strategies, to anticipate changes (e.g. by developing strategies with open options taking into consideration uncertainty), and to involve a wide range of actors in the governance process. Absence of opportunities for experimenting policy instruments.

Source: Technopolis Group (2018), Modified from Weber & Rohracher (2012)

Table 36: Failures in rail-related R&I

Market failures	
Externalities	The benefits of rail-related R&I are distributed broadly and do not necessarily correlate with the investment that individual organisations need to make. At the same time, the costs and risks associated with investment in R&I are high and the uncertainties surrounding the timing and level of returns tends to reduce levels of activity below the socially optimal level.
Information asymmetry	The European rail industry is fragmented in different ways, which increases the difficulty of sharing both the information needed to coordinate R&I activity and the results. This makes it difficult to ensure the progression of activity from basic research through development and demonstration to market take-up, since different actors with different information are involved at different stages of the R&I life cycle.
Systemic failures	
Capability	The capability of the European RSI, while currently world-leading, is increasingly being challenged by competitors in Asia and notably by the Chinese rail industry, which has established a leading position in fields such as high-speed rail. Historically, the level of R&I intensity achieved by the rail industry in Europe has also been significantly lower than that achieved by the aviation and automotive sectors. This reflects the more limited capability of a fragmented industry to coordinate R&I effort given the costs, risks and lead times involved in the distribution of associated benefits.

Network	It is difficult for rail industry organisations acting alone or through ad hoc consortia to build the network of rail operators, infrastructure managers, manufacturers and research and educational institutions necessary for effective collaboration and market-focused R&I. The fragmentation of the rail network itself is also a significant barrier to effective R&I effort. The persistence of differences in rail systems and standards similarly makes it difficult for individual rail organisations to coordinate research activity and build the consensus commercial case needed to secure market take-up of solutions at the pan-European level.
Institutional	The loose institutional framework provided by Framework Programmes before Horizon 2020 does not enable coordination of activity across a sufficient range of organisations to ensure that R&I activity is focused on key industry challenges, for example the development of freight and urban transport services. More generally, participation under such a framework tends to be based on the formation of ad hoc consortia in response to the requirements of particular projects rather than on consideration of long-term strategic needs. Rules on participation have also made it more difficult for SMEs with particular skills to participate in projects, for example by requiring participation from a minimum number of Member States.
Infrastructural	Similarly, Framework Programmes before Horizon 2020, while providing infrastructure to support open calls, did not provide for the dedicated management resources required to develop a long-term R&I strategy for the rail industry. Such a strategy requires a degree of central planning and coordination of inputs from a wide range of stakeholders who have little incentive to cooperate fully if left to work in isolation or through ad hoc collaboration. In addition, the generic infrastructure provided under Framework Programmes does not support regular and extensive interaction between research-based and rail industry organisations of the kind needed to build effective networks.
Transformational failures	
Directionality	Recent R&I activity has been directed towards key technical challenges faced by the European rail system. However, it has not taken full account of the needs of operators in key markets, for example freight operators and urban transport operators. More generally, work programmes have not always been sufficiently focused on encouraging market take-up of innovations through demonstration activity.
Policy coordination	Rail-related R&I promoted through previous Framework Programmes was not always fully aligned with EU policy objectives, including the objectives of SERA. More specifically, it was not sufficiently focused on addressing technical differences between rail systems and improving the attractiveness of rail services. This suggests that R&I activity supported by open calls alone under Horizon Europe would be similarly misaligned with broader rail policy.

E.2 Stakeholder participation

The table below summarises our analysis of the contribution of, and constraints on, different groups of stakeholders potentially participating in the Transforming Europe's Rail System iniative.

Table 37: Stakeholders contributing to rail-related R&I

Stakeholder group	Contribution	Constraints
RSI – key manufacturers	• Long term perspective on opportunities and challenges facing the RSI • Proposals for new R&I programmes generating outputs with practical application • Active participation in programmes across TRLs, particularly in support of demonstration and deployment • Resources in the form of funding and in-kind support	• In the absence of collaboration with train operators and infrastructure managers, lack the ability to fully demonstrate the benefits of innovation (requires collaboration with transport industry organisations capable of bringing an operational and customer perspective)
RSI – sub-suppliers including SMEs	• Long term perspective on opportunities and challenges facing the RSI • Expertise relating to specific parts of the value chain or individual technologies • Flexibility in responding to commercial opportunities created by new technological developments	• Limited resources, making it difficult to make a substantial financial commitment to collaborative R&I activity
Infrastructure managers	• Long term perspective on opportunities and challenges facing rail transport • Infrastructure asset management expertise • Proposals for new R&I programmes generating outputs with practical application • Validation of programmes from a user perspective • Active participation in programmes across the TRLs, including demonstration and deployment	• As regulated and/or public sector entities, typically subject to onerous financial monitoring arrangements. (e.g. Network Rail and Trafikverket operate within a strict financial framework under which R&I and other investment is subject to thorough scrutiny). • Seek clear, and ideally legally binding, commitments from partners when entering into joint funding arrangements

Stakeholder group	Contribution	Constraints
	• Resources in the form of funding and in-kind support	
Passenger train operators	• Understanding of the opportunities and threats facing the rail industry in the short to medium term • Understanding of the operational costs and benefits of new technology • Understanding of passenger requirements and expectations • Proposals for new R&I programmes generating outputs with practical application • Validation of programmes from a user perspective • Active participation in programmes across the TRLs, particularly in support of demonstration and deployment • Resources in the form of funding and in-kind support (in some cases)	• Take a short to medium term view, often determined by the term of rail service contracts - frequently less than 10 years (although incumbent operators of longer distance commercial services and open access operators have a longer-term perspective) • Have more limited access to funding for investment than infrastructure managers - costs and profits constrained by competition
Freight train operators and logistics service providers	• Understanding of the opportunities and threats facing rail freight and the freight transport industry more generally • Understanding of the operational costs and benefits of new technology • Understanding of freight customer requirements and expectations • Validation of programmes from a user perspective	• Have limited financial capacity to support R&I as they operate in highly competitive markets and are subject to low operating margins • Tend to have a short to medium term perspective

Stakeholder group	Contribution	Constraints
	• Active participation in programmes across the TRLs, particularly in support of demonstration and deployment • Resources in the form of in-kind support (in some cases)	
Urban transport operators	• Understanding of the opportunities and threats facing the urban transport sector at least in the short to medium term • Understanding of the operational costs and benefits of new technology • Understanding of passenger requirements and expectations • Validation of programmes from a user perspective • Active participation in programmes across the TRLs, particularly in support of demonstration and deployment	• Participation limited by public sector funding constraints and/or profitability
Universities and research institutions	• Understanding of the existing science knowledge base • Proposals for new R&I programmes at the lower TRLs • An ability to validate programmes from the perspective of 'good science' • Active participation in programmes across a range of TRLs, particularly 1-4	• Limited funding, although academic networks linked to industry may be able to provide support for specific research initiatives
Technology-based organisations	• Understanding of broader technological	• Generally unaware of the issues faced by the rail transport industry and RSI

Stakeholder group	Contribution	Constraints
outside the rail industry	developments of relevance to rail • Proposals for new R&I programmes across the TRLs • Active participation in programmes across a range of TRLs • Resources, at least in the form of in-kind support (in some cases)	• Not necessarily able to explain the benefits of new technology in a rail context
Port/ terminal operators	• Expertise in a key part of the freight logistics chain	• Benefits of involvement may be unclear or widely distributed
Certification bodies	• Can confirm that innovations can be applied and are compatible with standards	• May have limited time and resources

Source: Steer analysis based on stakeholder engagement

E.3 Evidence of market take-up rates

The challenge of coordinating activity along the innovation life cycle is demonstrated by an analysis, commissioned by ERRAC and undertaken by Foster Rail, of market take-up of rail-related R&I before the S2R JU was established.[77] This included an evaluation of 87 projects funded largely under Framework Programmes 4 to 7, with the evaluation work completed between 2006 and 2016. Based on interviews with project partners, the evaluators categorised the projects according to whether market take-up was considered strong, medium or weak using the criteria defined in the following table.

Table 38: Definition of market take-up criteria

Market take-up criteria	Definition
Strong	Clear evidence of use of products, services or processes, dissemination of knowledge or application of tools in several countries or products and that the major objectives of the project have been implemented. These projects will sometimes lead to additional research to realise their full market potential.
Medium	Some evidence of use of products, services or processes or limited dissemination of knowledge or application of tools in a few countries or products. A project was categorised as having medium take-up if only a small part of it was taken up by the market. In some cases, a follow-up project was considered necessary.

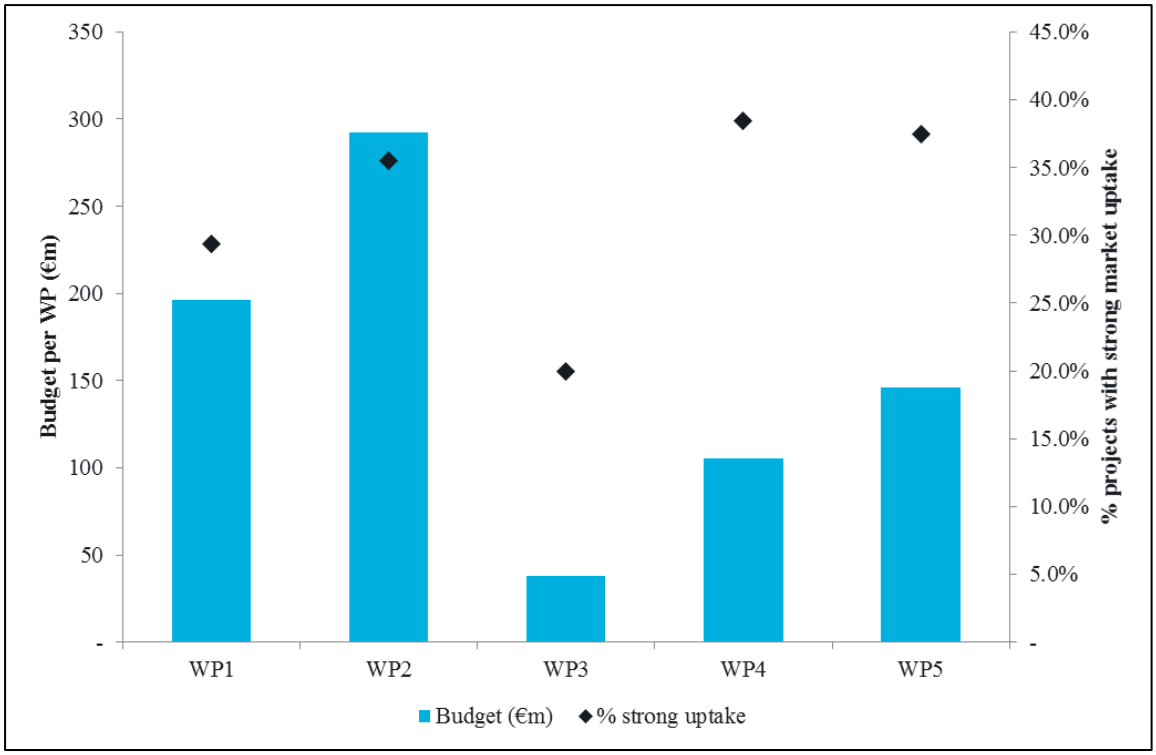
[77] See footnote 27.

Market take-up criteria	Definition
Weak	No known use of products, services, processes, knowledge or tools identified anywhere. No follow up project is needed unless the reason for the failure in take-up is clearly understood and removed.

Source: Foster Rail (2016), op. cit.

The projects evaluated were drawn from five separate work programmes, namely the greening of surface transport (WP1), encouraging modal shift and decongestion (WP2), ensuring sustainable (sub)urban transport (WP3), improving safety and security (WP4) and strengthening competitiveness (WP5). The percentage of projects considered to have strong take-up and the total budget for the projects by work programme are shown in *Figure 53*.

Figure 53: Market take-up of rail-related R&I projects evaluated between 2006 and 2016



Source: Steer analysis of data from Foster Rail (2016) op. cit.

Overall, some 33% of projects were considered to have strong market take-up and no work programme achieved a take-up rate of 40%. Moreover, there is no clear correlation between take-up rates and the size of the work programme budget, indicating that the availability of more resources does not necessarily encourage project partners to put in place the mechanisms needed to ensure high levels of market take-up.

Foster Rail also identified a series of lessons learned with a view to encouraging strong market take-up in the future, based on the results of detailed evaluation of individual projects. These echo the findings of Palacin et al (2016) and are summarised in Table 39.

Table 39: Lessons learned from evaluation of rail-related R&I projects

Project feature	Key lessons
Consortium building	• Involve key stakeholders who are committed to finding and applying viable solutions • Take account of strategic and commercial interests of different partners (e.g. asymmetric cost impacts) • Ensure partners have adequate financial capability
Ownership of project results	• Consider potential issues related to intellectual property rights at project inception • Consider related projects and set up a formal process to hand over results to sponsoring organisation
Development of business case	• Undertake relevant market analysis • Ensure implementation of results would not undermine strategic interests of stakeholders and that impact on future investment is considered • Identify viable solutions in terms of applicability and cost and ensure clear ownership of the results
Relations with other projects	• Avoid duplication/repetition of other projects and identify inputs from previous projects clearly • Identify any need for a follow-up project
Management of project	• Ensure that project objectives are fully achieved, taking account of strategic and financial considerations • Ensure coordination between different project consortia within a given area and seek to establish a common strategy • Establish clear communication channels within a consortium and undertake regular reviews of post-project progress
Dissemination/ exploitation of results	• Define the scope, inputs and deliverables at project inception and specify objectives and an implementation strategy or plan identifying specific potential users of the results • Establish a steering group of relevant experts and stakeholders to advise on exploitation of results • Plan methods of knowledge retention and dissemination at project inception

Source: Steer summary of conclusions from Foster Rail (2016) op. cit.

These conclusions tend to confirm the importance of effective coordination of activity along the innovation life cycle, including explicit consideration of links with previous and future R&I projects and communication with other project consortia working in the same area. However, given the level of industry fragmentation discussed in *Section 2.2.3*, achieving such coordination is likely to remain challenging.

E.4 Evolution of the problem

The following table sets out our view of how the problem and its effects might evolve over time, based on a review of available research on market take-up and consideration of the KPIs monitored by the S2R JU. Note that the data relating to changes in life cycle cost, punctuality and reliability and capacity are based on release 2.0 of the S2R JU's KPIs, as

reported to its Governing Board in November 2019. These provide a best estimate of the R&I results available to the industry at the start of Horizon Europe, but we note that they may change as further releases become available.

Table 40: Evolution of the problem

Parameter		Base position	Source	Commentary on starting point and evolution during period of Horizon Europe
Market take-up of innovation		33%	Foster Rail analysis	The figure represents the percentage of projects taken up by the market and can be considered a proxy for the percentage impact of a given R&I output on the market as whole under the baseline from 2022. Stakeholders have indicated the market take-up has been substantially higher since the S2R JU was established but it could be expected to fall under the baseline.
Life cycle cost	High speed	-15%	S2R JU	Figures represent the improvements in life cycle costs potentially available to the European rail sector by 2030 if outputs already achieved under Horizon 2020 are taken up across the system. They will therefore need to be combined with the market take-up assumption to generate an estimate of actual efficiency savings. Some additional efficiency improvements are likely to be generated through additional R&I activity and investment at the national level, but these are difficult to quantify.
	Regional	-19%	S2R JU	
	Urban	-15%	S2R JU	
	Freight	-26%	S2R JU	
Capacity	High speed	69%	S2R JU	Figures represent the improvements in capacity potentially available to the European rail sector by 2030 if outputs already achieved under Horizon 2020 are taken up across the system. They will therefore need to be combined with the market take-up assumption to generate an estimate of actual capacity increases. Additional improvements in capacity from network enhancements at the national level can be expected to continue but these are difficult to quantify.
	Regional	57%	S2R JU	
	Urban	23%	S2R JU	
	Freight	134%	S2R JU	
Punctuality/ reliability	High speed	29%	S2R JU	Figures represent the improvements in punctuality/reliability potentially available to the European rail sector by 2030 if outputs already achieved under Horizon 2020 are taken up across the system. They will therefore need to be combined with the market take-up assumption to generate an estimate of actual improvements in operational performance. There is no clear trend in punctuality or reliability of rail services (whether passenger or freight) in recent years with, for example the performance of services in many Member
	Regional	51%	S2R JU	
	Urban	-	S2R JU	
	Freight	78%	S2R JU	

Parameter	Base position	Source	Commentary on starting point and evolution during period of Horizon Europe
			States deteriorating between 2014 and 2016. Hence there is no reason to expect significant additional improvements beyond those made possible by R&I activity to date.
Passenger modal share	9.4%	Sixth RMMS[78]	The figure represents the total share of heavy and light rail of total land-based passenger-km in 2016. Note that we have combined heavy and light rail in view of the need expressed by some stakeholders to achieve greater integration of national and urban rail services during Horizon Europe. Given the stability of this share during FP 7 (and previous Programmes), we would not expect it to change materially under the baseline.
Freight modal share	17.4%	Sixth RMMS	The figure represents the total share of heavy rail of total land-based tonne-km in 2016. Given the stability of this share during FP 7 (and previous Programmes), we would not expect it to change materially under the baseline.

Source: Steer review based on individual sources indicated in the table

[78] European Commission (2019), Staff Working Document accompanying the document: Sixth Report on monitoring development of the rail market, February 2019, available at: https://ec.europa.eu/transport/modes/rail/market/market_monitoring_en.

Appendix F Additional information related to the problem definition

F.1 Taxonomy of failures requiring policy intervention

Market failures	
Market power	Limited interest from private sector parties to invest in R&D for the development of health technologies for PRNDs due to low potential for return on investment. Lack of universal health coverage means that individuals are often unable to cover the costs for treatments.
Externalities	There are weak and underfunded health systems in Africa. Capacity for conducting research in the region is similarly weak.
Information asymmetry	Pharmaceutical companies usually have a large extent of monopoly power, making it challenging for countries, in particular, LMICs, to negotiate affordable prices for health technologies.
Systemic failures	
Capability	Low capacity in Africa to conduct research and development locally
Network	Private sector parties have shown relatively limited interest in the development of suitable and affordable health technologies for PRNDs. Whereas public sector parties, including academic organisations, have shown greater interest in this, they usually lack the experience and resources to bring products through the clinical research and product development stages to bring a product to market. This calls for a partnership approach. Fragmentation in the research landscape should be reduced through stronger networking and a partnership approach.
Institutional	SSA countries require the development of a capacity to support the conduct of clinical trials in the region, including frameworks for regulatory oversight and medical ethics committees.
Infrastructural	Limited staff capacity for the conduct of clinical trials in the SSA region, as well as insufficient laboratory infrastructures (e.g. laboratory equipment, supply chain management systems, digital infrastructure to support data collection and analysis)
Transformational failures	

Directionality	Need for a strong partnership to agree on shared objectives and development of global R&D roadmaps e.g. for TB vaccine development
Demand articulation	Equal voice and representation of SSA countries helps to ensure that supported activities are aligned with the local needs and demands for products of greatest relevance to the region
Policy coordination	There are many different stakeholders and initiatives in the global health field. A partnership approach allows ensuring proper coordination and alignment.
Reflexivity	EDCTP has developed a strong results-based management approach which supports is the ability to monitor its impacts and make necessary adjustments along the way. A strong partnership is able to more rapidly respond to emerging needs, as in the case of the 2014 West Africa Ebola outbreak.

Source: Weber and Rohracher (2012) adapted by Technopolis Group (2018)

Appendix G Additional information related to the policy options descriptions

G.1 Degree of coverage of the different functionalities by policy option

Table 41: Type and composition of actors (including openness and roles)

Option 0: Horizon Europe calls	Option 2: Co-funded	Option 3: Institutionalised Art 185	Option 1: Co-programmed	Option 3: Institutionalised Art 187
What is possible? *Any legal entity* in a consortiu**m** can apply to Horizon Europe calls in ad hoc combinations Calls are open to participation from across Europe and the world (not all entities from third countries are eligible for funding)	***What is possible?*** Partners can include *any national funding body or governmental research organisation*, Possible to include also *other type of actors*, including foundations.	***What is possible?*** Partners can include *MS and Associated Countries*.	***What is possible?*** Suitable for *all types of partners*: private and/or public partners, including MS, regions, foundations. By default open to AC/ 3rd countries, but subject to policy considerations. Can cover a *large and changing community.* HE rules apply by default to calls included in the FP Work Programme, so any legal entity can apply to these.	***What is possible?*** Suitable for *all types of partners*: private and/or public partners, including MS, foundations. By default open to legal entities from AC/ 3rd countries, but subject to policy considerations. In case of countries participating non-associated third countries can only be included as partners if foreseen in the basic act and subjected to conclusion of dedicated international agreements HE rules apply by default, so any legal entity can apply to partnership calls.
What is limited? Systematic/ structured engagement with public authorities, MS, regulators, standard making bodies, foundations and NGOs.	***What is limited?*** Requires substantial national R&I programmes (competitive or institutional) in the field. Usually only legal entities from countries that are part of the consortia can apply to calls launched by the	***What is limited?*** Non-associated third countries can only be included as partners if foreseen in the basic act and subjected to conclusion of dedicated international agreements. Needs good geographical coverage – participation of at least 40% of Member States is required	***What is limited?*** If MS launch calls under their responsibility, usually only legal entities from countries that are part of the consortia can apply to these, under national rules	***What is limited?*** Requires a *rather stable set of partners* (e.g. if a sector has small number of key companies). Basic act can foresee exceptions for participation in calls / eligibility for funding.

Option 0: Horizon Europe calls	Option 2: Co-funded	Option 3: Institutionalised Art 185	Option 1: Co-programmed	Option 3: Institutionalised Art 187
	partnership, under national rules.	Requires substantial national R&I programmes (competitive or institutional) in the field. While by default the FP rules apply for eligibility for funding/participation, in practice (subject to derogation) often only legal entities from countries that are Participating States can apply to calls launched by the partnership, under national rules.		
What is not possible? To have a joint programme of R&I activities between the EU and committed partners that is implemented based on a common vision.	***What is not possible?*** To have industry/ private sector as partners.	***What is not possible?*** To have industry/ private sector as partners.		

Table 42: Type and range of activities (including flexibility and level of integration)

Option 0: Horizon Europe calls	Option 2: Co-funded	Option 3: Institutionalised Art 185	Option 1: Co-programmed	Option 3: Institutionalised Art 187
What is possible? Horizon Europe standard actions that allow *broad range of individual activities* from R&I to TRL 7 or sometimes higher. Calls for proposals published in the Work Programmes of Horizon Europe (adopted via comitology).	***What is possible?*** Activities may range from R&I, pilot, deployment actions to training and mobility, dissemination and exploitation, but according to national programmes and rules. Decision and implementation by "beneficiaries" (partners in the co-fund grant agreement) e.g. through institutional funding programmes, or by "third parties" receiving financial support, following calls for proposals launched by the consortium.	***What is possible?*** Horizon Europe standard actions that allow a broad range of coordinated activities from R&I to uptake. In case of implementation based on national rules (subject to derogation) Activities according to national programmes and rules. Allows integrating national funding and Union funding into the joint funding of projects	***What is possible?*** *Horizon Europe standard actions* that allow a broad range of coordinated activities from R&I to uptake. The association representing private partners allows to continuously build further on the results of previous projects, including activities related to regulations and standardisation and developing synergies with other funds Union contribution is implemented via calls for proposals published in the Work Programmes of Horizon Europe based on the input from partners (adopted via comitology). Open and flexible form that is simple and easy to manage.	***What is possible?*** *HE standard actions* that allow to build a portfolio with broad range of activities from research to market uptake. The back-office allows dedicated staff to implement integrated portfolio of projects, allowing to build a "system" (e.g. *hydrogen*) via pipeline of support to accelerate and scale up the take-up of results of the partnership, including those related to regulations and standardisation and developing synergies with other funds. E.g. setting up biorefinery plants and promoting their replication by additional investments from MS/ private sector. Procuring/purchasing jointly used equipment (e.g. HPC) Allows integrating national funding and Union funding into the joint funding of projects
What is limited?	***What is limited?*** Scale and scope of the programme the resulting funded R&I actions and depend on the participating programmes, typically		***What is limited?*** Limited control over precise call definition, resulting projects and outcomes, as they are implemented by EC agencies.	***What is limited?*** Limited flexibility because objectives, range of activities and partners are defined in the Regulation, and negotiated in the Council (EP).

Option 0: Horizon Europe calls	Option 2: Co-funded	Option 3: Institutionalised Art 185	Option 1: Co-programmed	Option 3: Institutionalised Art 187
	smaller in scale than FP projects			
What is not possible? To design and implement in a systemic approach a portfolio of actions. To leverage additional activities and investments beyond the direct scope of the funded actions				

Table 43:Directionality

Option 0: Horizon Europe calls	Option 2: Co-funded	Option 3: Institutionalised Art 185	Option 1: Co-programmed	Option 3: Institutionalised Art 187
What is possible? Strategic Plan (as implementing act), annual work programmes (via comitology). Possible also to base call topics on existing or to be developed SRIA/roadmap	***What is possible?*** Strategic R&I agenda/roadmap agreed between partners and EC Annual work programme drafted by partners, approved by EC Objectives and commitments are set in the Grant Agreement.	***What is possible?*** Strategic R&I agenda/roadmap agreed between partners and EC Objectives and commitments are set in the legal base. Annual work programme drafted by partners, approved by EC Commitments include obligation for financial contributions (e.g. to administrative costs, from national R&I programmes).	***What is possible?*** Strategic R&I agenda/roadmap agreed between partners and EC Objectives and commitments are set in the contractual arrangement. Input to FP annual work programme drafted by partners, finalised by EC (comitology) Commitments are political/best effort, but usually fulfilled	***What is possible?*** Strategic R&I agenda/roadmap agreed between partners and EC Objectives and commitments are set in the legal base. Annual work programme drafted by partners, approved by EC (veto-right in governance) Commitments include obligation for financial contributions (e.g. to administrative costs, from national R&I programmes).
What is limited? No continuity in support of priorities beyond the coverage of the strategic plan (4 years) and budget (2 years Annual work programme).				
What is not possible? Coordinated implementation and funding linked to the concrete objectives/ roadmap, since part of overall project portfolio managed by agency				

Table 44: Coherence (internal and external)

Option 0: Horizon Europe calls	Option 2: Co-funded	Option 3: Institutionalised Art 185	Option 1: Co-programmed	Option 3: Institutionalised Art 187
What is possible? Coherence between different parts of the Annual Work programme of the FP ensured by EC	***What is possible?*** Coherence among partnerships and with different parts of the Annual Work programme of the FP can be ensured by partners and EC Synergies with national/regional programmes and activities	***What is possible?*** Coherence among partnerships and with different parts of the Annual Work programme of the FP can be ensured by partners and EC Synergies with national/regional programmes and activities Synergies with other programmes	***What is possible?*** Coherence among partnerships and with different parts of the Annual Work programme of the FP can be ensured by partners and EC If MS participate: Synergies with national/regional programmes and activities Synergies with industrial strategies	***What is possible?*** Coherence among partnerships and with different parts of the Annual Work programme of the FP can be ensured by partners and EC Synergies with other programmes or industrial strategies If MS participate: Synergies with national/regional programmes and activities
What is limited? Synergies with other programmes or industrial strategies	***What is limited?*** Synergies with other programmes or industrial strategies	***What is limited?*** Synergies with industrial strategies	***What is limited?*** Synergies with other programmes	
What is not possible? Synergies with national/regional programmes and activities				

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