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Deliverable D 1.1
A comprehensive map of rail innovative research and key rail stakeholders

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1 Executive Summary

This document presents a **mapping** exercise in **rail innovative research** which looks at current situations and tendencies in rail research environment. The objective of it is to achieve a more successful research strategy by guiding further TER4RAIL actions focused on structuring interactions within and outside the railway sector. This will lead to better networking, cross-fertilisation, common collaboration and kick-starting of new ideas, constituting the basis of the **Rail Innovative Research Observatory (RIRO)**. The RIRO has been designed to provide rich qualitative data and gain insights on a variety of opinions around rail research and innovation.

The mapping exercise has been performed based on three pillars:

- reviewing the railway sector vision delivered in their dedicated policy and key strategic documents;
- understanding the view of rail research and innovation from the perspective of different rail stakeholders; and
- looking at rail research and innovation projects undertaken by the sector.

The analysis of **rail policy and strategic documents** has shown that, despite the complexity and heterogeneity of the approaches and interests of the stakeholders of the rail research and innovation framework there are several points of common understanding, namely:

- Due to its inherent characteristics, **rail should be the backbone of the future European mobility scheme.**
- In order to achieve and maintain this position, rail should target a series of **socioeconomic, institutional and technological challenges**, to generate an environment where rail is key for mobility services.
- To do so, **digitalization and automation** (amongst many others) are the most mentioned **enablers** that the rail sector needs to face to keep in pace with the developments of the transport sector.
- Finally, there is a general agreement on the **positive impact that the Shift2Rail Joint Undertaking** has reached aligning the vision of the whole rail sector and contributing to push results of research and innovation activities into the market.

The actions addressed to rail stakeholders have provided insights on how research and innovation is organised at railway entities, relevance of collaboration, relationship with other stakeholders and sectors, and perceived disruptive technologies and innovations in the medium and long term.

The results of an on-line survey performed have shown that:

- **Public research and innovation funding mechanisms**, at European and National / Regional levels, are **the reference** to railway stakeholders, both as a source of research and innovation funding as well as a tool to facilitate collaboration with other stakeholders. Other instruments mentioned as good tools to foster collaboration are events, conferences

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and workshops, technology platforms, and the establishment of alliances. The Shift2Rail Joint Undertaking and the Transport Research Arena are considered to have a positive impact in supporting collaboration on rail research and innovation.

- **Collaboration** with other sectors / technologies is usually taking place, mainly with stakeholders from other transport modes (automotive, aerospace, waterborne), as well as energy or infrastructure fields. Railway entities, as shown by the survey, use their own employees as a primary source to detect innovations, followed by technology monitoring tools, participation at associations and networks and scientific literature.
- Looking at the most promising technologies or innovations that have the potential to transform the rail sector, **digitalisation and materials** are the main factors considered by the survey participants, both in the medium as well as in the long term. In the next 5 years, **5G, automation, batteries, big data and energy** are also mentioned several times. Looking at the coming decades, **artificial intelligence, automation, power sources and autonomous mobility** are also appearing in the rankings. This is also in line with the data obtained from the analysis of rail policy and strategic documents.

Furthermore, information on rail research and innovation **projects undertaken by the sector** has been collected, identifying a total of 179 rail-related projects financed by **Horizon 2020** and seeking collaboration to gather rail research and innovation projects financed at national level by the European member states.

The Horizon 2020 **rail projects scan** has shown that despite more actions are concentrated around Shift2Rail and smart, green and integrated transport Societal Challenge's programmes, there is a wide range of instruments under which rail research and innovation has been financed, such as other societal challenges, Marie Skłodowska-Curie Actions, applications in satellite navigation, industrial leadership, SME Instrument, fast track to innovation, the public-private partnerships of Factories of the Future and 5G Infrastructure, and the ECSEL Joint Undertaking.

All the information has been made publicly available in an excel database, considered as a living document that facilitates the identification of actors, expertise, country distribution, possible financing instruments, among others, stimulating the transfer of knowledge and networking.

Finally, the information gathered on the exercise of mapping rail innovative research will be combined with the results of the identification of non-rail actors and pool of expertise and the concepts on 2050 new urban scenarios in order to guide and enrich the activities of the Rail Innovative Research Observatory that will focus on interacting, sharing experience and cross-fertilisation during the second half of TER4RAIL project.

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2 Objectives

The aim of this document is to deliver a comprehensive map of the state-of-the-art and major tendencies of innovative research in **rail technology** and **key stakeholders** in the **R&I of rail-related activities**. This has been accomplished through the following:

- Reviewing the key stakeholders' technological vision delivered in their dedicated policy and strategic documents in order to identify innovative research in the rail sector and future trends. The list of the selected 28 documents will be included in an Annex.
- Identifying the way in which innovations penetrate rail research through a questionnaire and in-depth interviews with selected rail stakeholders to find information regarding the mechanism of innovating in the rail system.
- Reviewing and analysed some of the most important research and innovation projects undertaken in the last five years to detect innovations. A list of 179 has been analysed, with priority to the Shift2Rail projects, other H2020 projects addressing rail research, SME instrument addressing rail research and other European Funded initiatives.

All this information builds this deliverable that maps, in a single document, the current situation of the rail R&I and will form the basis for the following tasks under WP1 (and other WPs).

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3 Abbreviations and acronyms

- ACARE, Advisory Council for Aeronautics Research in Europe
- ALAMYS, Asociación Latinoamericana de Metros y Subterráneos
- ALICE, Alliance for Logistics Innovation through Collaboration in Europe
- APVV, Slovak Research and Development Agency
- AT, Austria
- ATC, Automatic Train Control
- ATO, Automatic Train Operation
- ATP, Automatic Train Protection
- BE, Belgium
- BG, Bulgaria
- BIM, Building Information Modelling
- CAT, Connected and automated transport
- CCC, Command and Control
- CDTI, Centro para el Desarrollo Tecnológico Industrial
- CEF, Connecting Europe Facility
- CH, Switzerland
- COP, Conference of Parties
- CORDIS, Community Research and Development Information Service
- CY, Cyprus
- CZ, Czech Republic
- DE, Germany
- DG MOVE, European Commission's Directorate-General for Mobility and Transport
- DG RTD, European Commission's Directorate-General for Research and Innovation
- DG, Directorate-General
- DK, Denmark
- EC, European Commission
- ECSEL, Electronic Components and Systems for European Leadership
- EE, Estonia
- EGNOS, European Geostationary Navigation Overlay Service
- EIB, European Investment Bank
- EL, Greece
- EPSRC, Engineering and Physical Sciences Research Council from UK
- ERA, European Union Agency for Railways
- ERRAC, European Rail Research Advisory Council
- ERTMS European Rail Traffic Management System
- ES, Spain
- ESCRC, Economic and Social Research Council from UK
- ETP, European Technology Platforms
- EU, European Union
- EURNEX, European rail Research Network of Excellence

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- FFG, The Austrian Research Promotion Agency
- FI, Finland
- FP, Framework Programme
- FR, France
- FTI, Fast Track to Innovation
- GHG, Green House Gas
- GNSS, Global Navigation Satellite System
- HR, Croatia
- HU, Hungary
- ICT, Information and Communications Technology
- IE, Ireland
- IF, Individual fellowships
- IL, Israel
- IS, Iceland
- IT, Italy
- ITN, Research networks
- JU, Joint Undertaking
- LEIT, Leadership in Enabling and Industrial Technologies
- LI, Liechtenstein
- LT, Lithuania
- LU, Luxembourg
- LV, Latvia
- MaaS, Mobility as a Service
- MAFEX, Spanish Railway Industry Association
- MSCA, Marie Skłodowska-Curie actions
- MT, Malta
- NL, Netherlands
- NO, Norway
- Nox, oxides of nitrogen
- PL, Poland
- PPP, Public Private Partnership
- PT, Portugal
- R&I, Research and Innovation
- RISE, Research and Innovation Staff Exchanges
- RIRO, Rail Innovative Research Observatory
- RO, Romania
- RSSB, the Rail Safety and Standards Board
- RVO, Netherlands Enterprise Agency
- S2R, Shift2Rail
- SE, Sweden
- SERA, Single European Railway Area
- SI, Slovenia

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- SiC, Silicon Carbide
- SK, Slovakia
- SME, Small and Medium Enterprise
- SRG, States Representatives Group (SRG), body of the Shift2Rail Joint Undertaking
- SWOT, Strengths, Weaknesses, Opportunities and Threats
- TRIMIS, Transport Research and Innovation Monitoring and Information System
- TRIP, Transport Research & Innovation Portal
- TRL, Technology Readiness Level
- TSI, Technical Specifications for Interoperability
- UIC, International Union of Railways
- UITP, Union Internationale des Transports Publics
- UK, United Kingdom
- UNIFE, Association of the European Rail Industry
- VAST, Virtual Airspace and Tower
- VEGA, Scientific Grant Agency (Slovakia)
- WG, Work Group
- WP, Work Package

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4 A comprehensive map of rail innovative research and key rail stakeholders

The mapping of rail innovative research: current situation and tendencies, has been performed through the analysis of three pillars that will be described with detail hereafter:

1- Reviewing the railway sector vision delivered in key strategic **documents**.
2- Understanding the view of rail R&I from the perspective of different **rail stakeholders.**
3- Reviewing **rail research and innovation projects** undertaken by the sector.

Figure 1: Pillars of the map of rail innovative research

4.1 Rail policy and strategic documents

4.1.1 Methodology

Section 4.1 is based on the analysis of the selected 28 key strategic and policy documents, which have been selected by partners as the most relevant for the rail sector. The methodology for selection, assessment and analysis of documents was presented in detail in "MS1- A comprehensive map of rail innovative research and key rail stakeholders – Update", including the template for acquiring and analysing the information.

Sections from 4.1.3. to 4.1.7. have been built summarizing the analysis of the documents produced by task 1.1 partners. Section 4.1.2. has been produced by task 1.1 leader using information from the selected documents. The list of documents is attached in the Appendix 5.1.

Through the analysis of the most relevant rail policy and strategic documents, TER4RAIL aims to deliver the vision that maps current situation and tendencies of the rail system. A considerable

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number of relevant documents and sources have been included in this analysis, taking also into account the "ERRAC – 2030 R&I priorities towards ERRAC 2050 Vision" being elaborated by ERRAC at the moment of writing this deliverable. Despite not being available in a final version, it has been included due to its relevance as it represents a balanced and clear vision of the future of the R&D rail system.

4.1.2 Overview of the structure of railway systems

As described in the "Interim Evaluation of Shift2Rail Joint Undertaking (2014-2016)", it is important to have a quick outlook at the structure of the railway transportation system in Europe, especially for those who are new to the Rail environment.

Rail differs from many other sub-sectors of transport, such as aviation or road, in the sense that it is more constrained by a higher number of technical sub-systems rigidly interfacing with one another. These rigid interfaces are subject to regulation for reasons of compatibility and safety.

The whole railway system comprises of several sub-systems that exchange, through their various interfaces, both productive interactions (services and functions), and unproductive ones (constraints), the majority are of a highly technical nature (reflected in the high numbers of highly skilled engineers that are required for any rail network to function properly).

The rail sub-systems are recognized by the European regulations, and different Technical Specifications for Interoperability (TSI) are allocated. These are divided into two main areas:

Structural sub-systems:
Rolling stock (rail vehicles)
Control-command (ATP, ATC, ATO7) and signalling
Infrastructure (including tracks and their sub-structure, bridges and tunnels, stations etc.)
Energy feeding system (electrification)

Functional sub-systems
Operations
Maintenance
Telematics applications for freight and for passengers (this being the only part of a wider telecommunications subsystem that is considered by the interoperability directive)

The railway transport ecosystem is further complicated by its fragmentation into a number of **transport services** that interconnect to some extent but have different profiles, regulations and standards:

Urban rail services (outside the scope of the EU Interoperability and Safety Directives and outside of the SERA)
Suburban and regional services
Intercity services (including high speed)
Freight services

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These service categories bring in a number of different **players** into this ecosystem:

- Urban operators,
- Main line railway undertakings (passengers and/or freight), either incumbent national operators, regional operators or freight transport "new entrants"
- Main line infrastructure managers, generally in charge of a national network at the scale of the territory of a Member State
- Maintenance companies
- Rolling stock owners and lessors etc.
- Rail suppliers
- Rail related logistics companies

Any initiative taken to improve the overall performance and attractiveness of the European railway system should therefore also involve a broad range of market players representing the 'ecosystem' of the European railway sector. Shift2Rail is seen to play an important role in bringing all these players together, and thus aligning developments to transform the European rail system as the backbone of the mobility. Amongst others, its objectives are to reduce costs and speed up the deployment of innovations.

The Rail R&I framework

Innovation and research is seen as a key instrument to deliver policy goals, as set out the White Paper and SERA. In this respect, the Horizon 2020 Shift2Rail JU is responsible for managing all direct rail research and therefore integrates and coordinates all R&I activities specific to rail. Compared to previous FP research this will help to avoid fragmentation and ensure continuity. In addition, in terms of EU added value, the leverage effect brought by the members' participation through in kind contributions and long-term commitment is considered to be higher than before.

The European Rail Research Advisory Council (ERRAC)

European Technology Platforms (ETPs) are industry-led stakeholder fora recognised by the European Commission as key actors in driving innovation, knowledge transfer and European competitiveness. ETPs develop research and innovation agendas and roadmaps for action at EU and national level to be supported by both private and public funding. They mobilise stakeholders to deliver on agreed priorities and share information.

There are five transport related ETPs, ACARE (aviation), ALICE (logistics), ERRAC (rail), ERTRAC (road) and Waterborne (maritime). ERRAC was set up in 2001 to help the establishment of a single European body with both the competence and capability to support the revitalisation of the European rail sector and make it more competitive, by fostering increased innovation and guiding research efforts at European level. All major rail stakeholders are gathered within ERRAC, gathering a wide range of European rail sector stakeholder organisations and their members, such as: manufacturers, operators, infrastructure managers, the European Commission, EU Member States, academics and users' groups. ERRAC covers all forms of rail transport: from conventional, high speed and freight applications to urban and regional services.

ERRAC's role is to define the research needs in order to realise the objectives of the Europe-2020 strategy, support the on-going European Framework Programme for research and development,

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Horizon 2020, support the objectives of the 2011 White Paper and support the development of the future European Framework Programme for research and development Horizon Europe. It is therefore perfectly set up to help provide guidance to S2R. However many members of ERRAC being involved in S2R, it had required a certain time to define and implement the cooperation between ERRAC and Shift2Rail JU.

The Shift2Rail Joint Undertaking

The Joint Undertaking Shift2Rail (S2R) was created to respond to the objectives defined in the White Paper, namely the goal of strengthening the role of rail in the transport system, given its inherent advantages in terms of environmental performance, land use, energy consumption and safety. A key initiative in achieving this goal is also the creation of a Single European Railway Area (SERA). It is recognised that there is a need for significant progress to be made by the sector in terms of efficiency, reliability, sustainability and more generally, user-friendliness and attractiveness.

The S2R JU is tasked with implementing a strategic Master Plan and Multi Annual Action Plans, which identify the major objectives of Shift2Rail as follows, closely related to the strategic context and EU policies:

- Supporting the achievement of the Single European Railway Area (SERA) through the development of solutions facilitating the removal of remaining technical obstacles in terms of interoperability; and make the transition to a more integrated, efficient and safe EU railway market, guaranteeing the proper interconnection of technical solutions.
- Radically enhancing the attractiveness and competitiveness of the European railway system to ensure a modal shift towards rail through a faster and less costly transition to a more attractive, user-friendly (including for persons with reduced mobility), efficient, reliable, and sustainable European rail system.
- Helping the European rail industry to retain and consolidate its leadership on the global market for rail products and services by ensuring that Research & Innovation activities and results can provide a competitive advantage to EU industries and by stimulating and accelerating the market uptake of innovative technologies.

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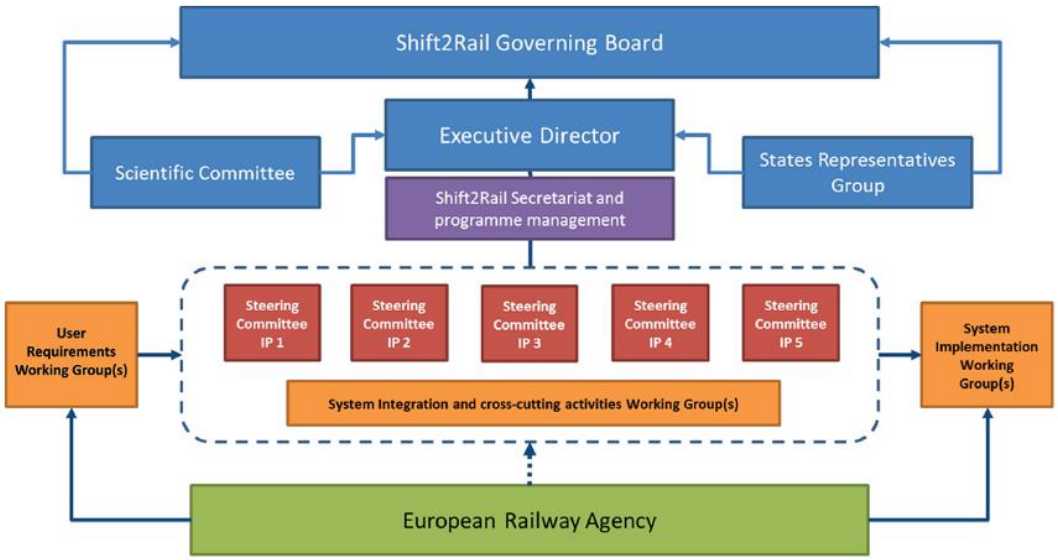

Figure 2: Shift2Rail organisational scheme. Source: Shift2Rail website.

Shift2Rail is technically and administratively organized following the above scheme. In this sense, and as previously, explained, ERRAC has the aim of giving a "whole system approach" guidance to the S2R JU.

4.1.3 The rail sector description

A summary of the state of the sector is developed, as expressed in the key strategic and policy documents.

General vision of the sector and mobility

- The rail transport is a key mode of transport that has to adapt to the new integrated and connected mobility landscape. Rail transport is in competition with other modes of transport and contributes to the mobility of the future as it brings many benefits notably in terms of capacity, low carbon footprint, comfort and safety, and shall become the backbone of the mobility of the future. The railway sector provides mass transit, journey comfort, safety, reduced land use, a low carbon footprint and energy efficiency
- Europe's railway network is the heart of its mobility, serving the travel needs of its citizens and playing a key role in the distribution of the goods they use. Innovative technologies have contributed to rail's growing share of the passenger market, which increased by 17% from 2001 to 2012[1].

[1] "Rail 2050 Vision. Rail-The backbone of europe´s mobility". ERRAC (2017)

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- Moreover, rail stations can be transformed into smart urban ''hubs'', bringing all the public transport modes together under one roof – train, bus and tram, and with good accessibility for pedestrians & cyclists.

Economy

- Railway transported products account for more than 20% of EU exports of goods and 8% of EU exports of services[2]. The railway remains at the heart of transport as the backbone of mobility, being instrumental in the different industrial revolutions.

Workforce and labour

- Rail utilizes and promotes the development of skilled labour, serving as a catalyst for economic growth whose value is often underestimated. The rail sector provides 400 000 high-skilled jobs within European manufacturing industries, including numerous SMEs. The railway sector overall, including maintenance and operations, is responsible for more than 1 million direct and 1.2 million indirect jobs in the EU[3]. The rail sector has a role to play in the reindustrialization of Europe by creating jobs and stimulating growth.
- European rail mobility is sustained by a skilled workforce. Nevertheless, some 30% is expected to retire in the next 10 years and on the other hand, there is a need to ensure that skills and competencies are brought into accompanying the major transformation process driven by research and innovation[4].

Environment: Energy, Air Quality and Noise

- The greenest mode of transport: Rail transport is recognized today as the most environmentally friendly form of mass transport. With an average consumption of 0.12 kWh per passenger-km, urban rail is 7 times more energy efficient per passenger than car travel in cities. In 2011, CO2 emissions from road transport were 2.6 times those from the rail in passenger-kilometres and 3.6 in tonne-kilometres[5].
  Railways have improved their energy efficiency, thus becoming more CO2-efficient for both passenger and freight transport. For instance, the energy consumption of vehicles improved by 20% from 1990 to 2010. On certain types of vehicles, savings are estimated to represent as much as 50%. In 2015 the European railways committed to reducing their specific CO2 emissions from train operations by 40% by 2020 compared to 1990. They also have committed to a 30% reduction of the total CO2 emissions by 2030 relative to 1990, despite the envisaged modal shift in line with the White Paper goals[6].
  Rail is expected to achieve further energy savings thanks to lighter materials in vehicles and wider use of energy recuperation devices (e.g. regenerative braking or energy storage technologies).

[2] "Shift2Rail Multi Annual Action Plan". Shift2Rail (2017)
[3] "Shift2Rail Multi Annual Action Plan". Shift2Rail (2017)
[4] "Rail 2050 Vision. Rail-The backbone of europe´s mobility". ERRAC (2017)
[5] "Rail 2050 Vision. Rail-The backbone of europe´s mobility". ERRAC (2017)
[6] "Strategic Transport Innovation Agenda-Transport Electrification Roadmap". European Commission (2016)

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- Rail is key for the decarbonisation of transport: Rail transport remains the most efficient transport mode to decrease congestion and air pollution as well as move a large number of citizens in a sustainable way. Rail in Europe is mostly electrified and therefore a key to decarbonizing transport.
  Rail is the transport mode that is proportionally least dependent on fossil fuels. Petroleum-based products accounting for 33% of energy consumption[7]. The dominant alternative is electricity, with some biofuel consumption in the form of biodiesel. Especially in urban areas, rail almost exclusively runs on electricity already today. Regarding main lines, 60% of the European rail network is already electrified and 80% of traffic is running on these lines[8].
  Electrified rail is already using a significant share of renewable energies and further increasing their use. According to the International Energy Agency, 40% of the electricity mix used by railways in Europe is low-carbon, which originates with an average of around 20% from renewable sources[9].

- Electric trains do not directly generate air-pollutant emissions locally; any emissions that occur are created when traction current is generated, and new filters are helping to reduce these emissions as well.
  With regards to diesel propulsion, newly purchased engines for rail vehicles are regulated by the Non-Road Mobile Machinery Directive, which significantly reduced the particulate matters and NOx emissions of engines used for rail applications. In addition, modern diesel multiple units and locomotives with diesel-electric drive system provide fewer pollutants. They are sometimes equipped with several engines that can be partially switched off when not required, and particulate filters are mounted on these engines. Hydrogen trains are being tested in some parts of Europe and are seen as many as playing an important role in the future rail system.

- Rail freight noise is the most sensitive environmental problem of the railway sector and a serious nuisance for citizens living close to railway lines. 12 million EU inhabitants are affected by it during the day and 9 million during the night[10]. A study edited by the European Commission's Directorate General for Internal Policy lists measures, funding and regulations to reduce it.
  For electric trains, pantograph noise is also significant at high speed. Pantographs are generally higher than noise barriers, and for high-speed trains these are a major source of the noise. Rather than making noise barriers even higher or all-enclosing, an alternative approach is to focus on aerodynamic design and new materials. Pantographs can be shielded and/or carefully shaped, and thereby achieve noise reductions of 5-10 dB in each case[11].

[7] "Strategic Transport Innovation Agenda-Transport Infrastructure Roadmap". European Commission (2016)
[8] "Strategic Transport Innovation Agenda-Transport Electrification Roadmap". European Commission (2016)
[9] "Strategic Transport Innovation Agenda-Transport Electrification Roadmap". European Commission (2016)
[10] "Strategic Transport Innovation Agenda-Transport Electrification Roadmap". European Commission (2016)
[11] "Strategic Transport Innovation Agenda-Transport Electrification Roadmap". European Commission (2016)

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Policy

The main policies affecting the rail sector and its R&I activities are: The Roadmap to a Single European Transport Area (EC White Paper) and Horizon 2020 (concerning R&I issues, especially as this program gathers the Shift2Rail JU).

White Paper on transport sets an ambitious goal of reducing by 60% greenhouse gas emissions from transport by 2050 compared to the level of these emissions in 1990. To achieve this, overall objectives regarding modal shift have been set, such as a 30% shift of EU road freight over 300 km to more sustainable modes of transport (i.e. rail and waterborne transport) by 2030 (and more than 50% by 2050)[12]. Additionally, the 2011 White Paper on transport proposes that by 2050, the majority of medium-distance passenger transport should be by rail, and that by the same year a European high speed rail network should have been completed. In particular, the Single European Rail Area (SERA) will have a dramatic effect on the cost of passenger and freight trains by providing a common framework of rules and regulations for rail operators.

Other

Collaboration: The rail sector in Europe in recent years has through collaboration involving both public and private bodies, government, major companies, thousands of small and medium enterprises, academia and research laboratories—successfully maintained the world leading role of its manufacturing and rail supply industry, despite strong and increasing international competition especially from Asia. This has required the twin forces of the 'pull' from a sector responding to more demanding customer requirements, and the 'push' of a highly innovative supply chain encouraged to invest in relevant solutions in the technical, operational and service domains.

4.1.4 Trends and challenges

This section aims to understand the trends, challenges, opportunities and barriers that will influence the future of rail, with a special scope on the Rail R&I ecosystem.

The following table summarizes this section.

[12] "Research for TRAN Committee - Modal shift in European transport: a way forward". European Parliament (2018)

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Trends	Challenges	Opportunities	Risks	Barriers
Climate change, environment and growing interest for environmental issues	Climate change and urbanisation	SERA and Environmental regulations	Complex interactions between different rail segments and the need for synchronicity between innovations	Fragmentation among railway ecosystems
Urbanisation	Industrial and transport sector competitiveness	Increasing international demand for new rail lines	Long product life-cycles	Fragmentation among the subsystems of the rail sector
Transport demand growth	Capacity, quality of service, Cost and Oil prices	Enabling technologies and competitiveness	Unequal distribution of innovation benefits, reducing incentives to invest in new technologies	Fragmentation along the innovation life cycle
Demographic changes, ageing population and new societal trends	Deployment, standardisation and the future of know-how and innovation management	Opportunity to become the backbone of the future mobility schemes	Lack of synergies with other industrial sectors	For freight (i)Lack of cross-border interoperability (ii)Complexity of transport chains (iii)Slow implementation of the measures needed to deliver a single European rail transport network (iv) Slower technological innovation in the rail freight sector (v) Lack of knowledge and sufficient exchange of information
Technology, innovation and digitalisation	Infrastructure aspects		Competition with autonomous and alternatively propelled car systems	For medium-distance passenger transport use (i) Insufficient development of the high-speed rail network; and (ii) challenges posed by modes constituting an alternative for the road transport, particularly in terms of convenience and price (iii) Lack of competition in high speed rail services.
Competition with autonomous and alternatively propelled car systems	Safety and security			For urban areas (i)Transport and land use planning has facilitated the use of private motor vehicles above other modes (ii) Lack of integration within public transport

Table 1: Summary trends & challenges

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4.1.4.1 Trends

- *Climate change, environment and growing interest for environmental issues:* At global level further improvement is expected to reduce GHG emissions and be aligned with the targets of COP21[13]. More resilient infrastructure with improved emergency maintenance services are foreseen by experts towards 2050, including passenger information which in case of disruption also provides travel alternatives to reach destinations in time. The smart grid of the future will not be limited to the energy system but will represent a generalised facility for the future transport and rail network in general. Noise also remains a key issue for railways. Long distance rail travelling services must face the effect of climate change Shift2Rail is willing to promote the direction towards a railway producing 'no carbon, no emissions, no noise'.
  Public health considerations are driving increasing concern about the impact of road vehicle emission of particulates, both exhaust and non-exhaust. The noxious effect of the latter – caused by brake and tyre wear, road surface erosion and road dust particles – will still threaten public health even in the era of e-vehicles.
  The European Environment Agency calculates that almost 487,600 premature deaths in 2014 in the EU were attributable to PM2.5, NO2 or O3 exposure (not all being road-vehicle related). To put this in context, road traffic accidents resulted in 25,700 fatalities that year[14]. By comparison, in 2016, there were only 31 rail-related fatalities resulting from collisions with obstacles (other than incidents involving level crossings), collisions between trains, derailments, fires in rolling stock, electrocutions, shunting operations and accidents involving dangerous goods.

- *Urbanisation:* Demand for rail transport is expanding worldwide, particularly in metropolitan areas, with increasing urbanization. The railways have an advantage through their capacity to move very large numbers of people to alleviate the urbanization challenges. Shift2Rail wants to build on this advantage by increasing the capacity of the system and enhancing the integration with other modes leading to attractive end-to-end journey provision.
  Urban and heavy rail are further converging in urbanised areas and with regional rail into tram-train or metro-train (regional metro) concepts. High speed rail may promote lifestyles in which long distance commuting on a daily, week-end or some days per week frequency become an increasingly common phenomenon.

- *Demand for transport* has continued to grow, not just when measured in terms of share of GDP but also when judged in terms of the quality of service sought, while efficient transport continues to be seen as a cornerstone of European integration[15].

[13] Proposed since September 2018. The **Paris Agreement** (French: **Accord** de **Paris**) is an **agreement** within the United Nations Framework Convention on **Climate** Change (UNFCCC), dealing with greenhouse-gas-emissions mitigation, adaptation, and finance, ratified in the year 2016.
[14] https://ec.europa.eu/transport/sites/transport/files/road_safety/pdf/vademecum_2015.pdf
[15] *Transport in the EU, Current Trends & Issues*, DG MOVE, April 2018

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- *Demographic changes, ageing population and new societal trends:* The average age of citizens is increasing, as is the number of people with physical impairment to their mobility. Transport will have to adapt to this new demographic landscape by offering dedicated services to an older population. In terms of social aspirations, it is also expected that more than 50% of the world population will belong to the middle class by 2030. New behaviors will appear and create new needs (sharing schemes, smart services, immediacy).

- *Technology, innovation and digitalisation*: Innovations are expected to operate towards more energy and resource efficient systems for rolling stock and infrastructure and to converge towards a worldwide more and more "digital railway". Integrated services for ticketing and traveler information and guidance, also in case of disruption, are expected to be further improved towards real time level. There will also be a worldwide convergence of quality, safety and security management systems based on best practice and the vision of a global rail system with a maximum degree of interoperability and a global railway supply market.
  Shift2Rail will harness the capabilities of the digital revolution to transform the mobility system with rail as the backbone. The aim is to implement digital solutions through research, innovation and system architecture definition.
  Major innovation trends in the rail sector are based on integration technologies, i.e. analogue components converging more and more with digital (computerised equipment, servers, sensors... interconnected by different more and more open communication networks...). Rail users are expecting full functional digital communication and information transmission travelling by rail.
  It is important to attract new talents to transport business with the right set of skills and that is now essential to operate and maintain a digitised public transport system.

- Semi or fully autonomous and alternatively propelled car systems are seen to be a major competitor in 2030 to electrified rail mass transit if they can reach and demonstrate the safety level expected for driverless and public transport. However, limited range will continue to restrict the use of electric road vehicles for long distance passenger traffic and heavy freight. In dense and urbanised metropolitan regions of tomorrow it is expected that rail transit will retain its major role, which is to prevent congestion and open space consumption by moving and parking cars.

4.1.4.2 Challenges

- *Climate change:* Rail faces new challenges associated with climate change, including previously rare weather events, variations in temperature, more intense storm activity and rising sea levels. There is a need for more resilience in transport solutions, incorporating rail's inherent strengths.

- *Increasing urbanisation and strengthening the role of rail in the European transport system and the global competitiveness of European industry*: The increasing pace of urbanisation will dramatically increase the demand for efficient and sustainable transport solutions. To

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enhance the competitiveness of Europe, increased freight transport demand requires greater efficiency in freight delivery. Europe has to be aware of the uprising countries.

- Quality of service: There is a lack of a user-friendly transport mode, low on reliability and punctuality of service. Adopting a culture of service excellence is a response to the increasing and ever-changing needs and expectations of customers, while successfully providing them with a positive experience. With the mobility landscape changing quickly the 2030 railways sector will answer the evolving needs of end-users/citizens and businesses: attractiveness and convenience need to be provided in real-time, tailored within an end-users/citizens-centric environment through an integrated door-to-door mobility system that provides a punctual, reliable, safe, secure and comfortable service.

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

- *Road transport* is likely to become more competitive – as will other modes - with the development of autonomous vehicle technologies and vehicle connectivity. The successful development of e-vehicles, road electrification and initiatives like the introduction of platooning in the road freight sector will also have a significant impact on the economics and nature of road transport.
  Development of micro-mobility vehicles (sometimes defined as road vehicles weighing less than 500 kg and including e-bikes and e-scooters) could lead to major changes in vehicle use as well as in reducing the demand for road space, particularly in urban environments. They typically lend themselves to organised sharing, especially if their flexibility is unconstrained by the need for docking-stations. Micro-mobility, possibly combined with vehicle-sharing, may replace many of the short trips currently made by car. Besides making cities more livable, this could lead to more investment in public transport, including rail. The uptake of new micro-mobility solutions is likely to develop quickly and could impact on the transportation sector long before there are significant numbers of electric or autonomous vehicles. The railways are preparing for this eventuality.

- *Cost:* Public investment in infrastructure and service must be optimized, decreasing the cost per output unit, integrating the European market. It should be paid special attention to revisiting the governance of urban transport in a changing landscape with the emergence of new players disrupting the existing market. Digitalisation and electrification also have an impact on the cost structure of providing and operating public transport.

- *Deployment/Standardisation*: Implementing quickly ERTMS, development/update of EN standards based on research and innovation outputs, increasing harmonisation of

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operational rules/procedures and reducing national rules. Highly defragmented picture of national railway regulations and (CAT) technical solutions among European countries.

- *Infrastructure:* Increasing the trade, travel and urbanisation drives the need for new infrastructure as well as upgrading/legacy infrastructure.

    - *Governance:* This issue relates to the long life and expense of infrastructure and the short-term approach of many politically driven planning and investment decisions and public opinion. Where the focus is on high-level policy, the impact is positive in bringing about a planned and consistent wave of investment. But where the focus is on individual projects or locations the result can be delay, or abandonment of an otherwise sound investment. A key challenge for the European Commission and Member State Governments is to address transport externalities for different modes, considering emissions, noise, waste production, protection of the environment, accidents, etc.

    - *Pricing, taxation and finance:* Pricing is recognised as an effective mechanism for incentivising efficient decision making for transport use. A key challenge is to set up a smart infrastructure charging and financing policy across modes is one of the key challenges of the EU to reach the objectives of the Framework Strategy for a resilient Energy Union with a forward-looking climate change adaptation and mitigation policy.

    - *Synchromodality, intermodality, interoperability and integration of transport systems*: The challenges for both freight and passenger transport systems start with the need to design and operate around customer need, and to develop customer centric transport to make intermodal transport work. This, in turn, should lead to a reduction in the currently unacceptable lack of integration between transport modes.

    - *Life cycle optimisation*: One of the biggest challenges facing transport infrastructure and the decision to invest in infrastructure is to only build the infrastructure that is really required. Better operational practice combined with full exploitation of digital and control technology mean that new infrastructure is not necessarily the correct option. Strategies like autonomous driving, demand management, improvement of air traffic control or implementation of European Rail Traffic Management Systems are examples of best practices with a high potential to maximize asset utilization. Infrastructure owners shall be aware about the positive impacts and benefits of these developments on their systems.

    - *Infrastructure operation.* For rail, the transition of railway signalling from conventional systems to fully digital railway with European Rail Traffic Management System (ERTMS) is a once in a lifetime opportunity to increase

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capacity. But this opportunity comes with the risk of bespoke national / member state solutions and high cost eroding many of the potential benefits.

- *Know-how and innovation:* There is a major gap in engineering skills and there is a need to press not only on the short/medium terms problems, but have a more ambitious future rail sector, think faster, differently, in partnerships and open collaboration

- *Safety and security:* They have to be maintained at its high level, with harmonization of criteria benefiting rather than hindering this. Developing a new concept of operations for safe control of trains

- *Data privacy and data management:* Data support systems that are secure, robust, scalable and resilient.

- Oil prices

4.1.4.3 Opportunities

- *SERA and Environmental regulations:* Recent developments, such as the establishment of the Fourth Railway Package's technical pillar and the S2R Joint Undertaking, are supporting the creation of a Single European Rail Area (SERA)[16]. Stringent regulations on emissions are heavily influencing the planning and operation of transport systems, encouraging the development and use of greener modes of travel such as rail. Increased urbanisation, road congestion and polluting emissions will require alternative modes of transport to comply with environmental targets and reduce energy consumption, thus promoting rail use as a fundamental element of the solution.

- *Increasing international demand for new rail lines:* Huge rail and metro investment programmes outside Europe present an opportunity to supply not only products but also skilled teams for design, operation, and maintenance.

- *Enabling technologies and competitiveness:* The emergence of enabling technologies, such as artificial intelligence, the "internet of things", robotics, vehicle-to-vehicle and vehicle-to-infrastructure communications, autonomous driving and block-chain will provide a wide range of possibilities for innovation in the rail system and to change the way it operates, supporting improvements in rail-based logistics and mobility in the short run. These technologies will also help *identify and establish new market segments for exploitation* as they create an opportunity to exploit railway assets and strengths to open new markets and services (e.g. exploitation of underused capacity and network branches). Also, there is an opportunity to boost competitiveness through a skills development approach will create an opportunity to engage with diverse young citizens to attract them to the rail industry.

[16] https://ec.europa.eu/transport/modes/rail/news/2019-05-16-single-european-railway-area_en

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- *To become the backbone of current and future mobility concepts and on-demand future logistics*: Research and innovation, new technologies and digitalization create an opportunity to capitalize on the strengths of the railway integrating it with services covering the first and last miles. It will also enable to achieve transformative integration of the sub-systems that make-up railway.

4.1.4.4 Risks

- Complex interactions between different rail segments and the need for synchronicity between innovations.

- Long product life-cycles (of 30 years or more), inhibiting the rapid deployment of new rail technologies.

- Unequal distribution of innovation benefits between stakeholders, reducing incentives to invest in new technologies.

- Lack of synergies with other industrial sectors, especially in emerging technologies.

- Semi or fully autonomous and alternatively propelled car systems are seen to be a major competitor in 2030 to electrified rail mass transit if they can reach and demonstrate the safety level expected for driverless and public transport. The limited range of current battery technology may continue to restrict the use of electric road vehicles for long distance passenger traffic and heavy freight, however this may be solved or other clean fuels such as hydrogen deployed. In dense and urbanised metropolitan regions of tomorrow it is expected that rail transit will retain its major role, which is to prevent congestion and open space consumption by moving and parking cars.

4.1.4.5 Barriers

- Specific barriers for rail freight use are:
  An ongoing lack of cross-border interoperability; (ii) the complexity of transport chains, which is a particular challenge for multimodal chains; (iii) slow implementation of the measures needed to deliver a single European rail transport network; (v) slower technological innovation in the rail freight sector; and vi) a lack of knowledge and sufficient exchange of information.

- Specific barriers for medium-distance passenger transport use are:
  An insufficient development of the high-speed rail network; and (ii) challenges posed by modes constituting an alternative for the road transport, particularly in terms of convenience and price, and a lack of competition in high speed rail services.

- Specific barriers in urban areas use are:
  transport and land use planning that has facilitated the use of private motor vehicles above other modes; and (ii) lack of integration within public transport.

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In the Commission Staff Working Document and summary of the impact assessment (COM(2013) 922 final) to accompany the Proposal for a Council Regulation to establish the Shift2Rail Joint Undertaking the following four key drivers were noted as being **barriers** to achieving the SERA:

- Fragmentation among railway ecosystems, with a patchwork of disparate regional and national systems, networks and technical operating standards. The industry has to develop tailored vehicles/and rolling stock, designed to meet the unique constraints of relatively small national markets. This high level of product customisation constitutes a barrier to the SERA, but it also results in increased production costs.

- Fragmentation among the subsystems of the rail sector. Complex interactions between subsystems (infrastructure, rolling stock and signalling equipment manufacturers, railway undertakings and infrastructure managers) limit the potential of improving one specific part of the system or of proposing breakthrough solutions that have an impact on the whole system and that can be deployed in the complete SERA. To give one example: there are something like 14 different signalling systems across Europe that have to be brought together. This is time-consuming as well as expensive as firstly a consensus needs to be reached, then common standards agreed and finally the national systems need to change.

- Fragmentation along the innovation life cycle. In FP7, EU research efforts focused primarily on pre-competitive innovation research at low Technology Readiness Levels. There have been few large-scale demonstration projects (now a major component of S2R) and a significant part of knowledge generated by the European R&I projects have not been taken to market.

4.1.5 Rail vision

This section presents a summary describing how future rail should look like in order to successfully tackle the trends and challenges described in the previous section.

The Transport White Paper goals related to rail are:

For passenger rail:

- Triple the length of the existing high-speed rail network by 2030 so that, by 2050 the majority of medium-distance passenger transport should go by rail and high-speed rail should outpace the increase in aviation for journeys up to 1000 km;
- By 2050, connect all core network airports to the rail network, preferably high-speed;
- By 2020, establish the framework for a European multimodal transport information, management and payment system.

For freight:

- 30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050;

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- Rail freight should be almost doubled – +360 billion ton-km (+87%) compared to 2005;
- Deployment of ERTMS on the European Core Network by 2030;
- By 2050, connect all seaports to the rail freight system;
- Rail Freight Corridors as the backbone of the EU freight transport system.

For urban mobility:

- Halve the use of 'conventionally-fuelled' cars in urban transport by 2030; phase them out in cities by 2050;
- Achieve essentially CO2-free city logistics in major urban centres by 2030;
- By 2020, establish the framework for a European multimodal transport information, management and payment system.

In 2050, the European rail sector is a major agent of social and economic transformation and an integral component of the new European industrial base. Through the use of breakthrough technologies it has become a natural extension of the citizens' work and leisure environment, providing the backbone of European mobility and logistics solutions that safely and reliably interconnect communities, connecting producers to markets, and people to jobs and social activities-at a minimal cost, while making the most efficient use of scarce resources, particularly land and energy. The railway sector is outward-looking with global horizons, ready to learn from others and open to further change.

- *A railway serving society:* The innovation-powered transformation of the European rail sector gives it unprecedented technological and operational capabilities, which enable it to serve society with new concepts, products and services. These will be focused on mobility, logistics, smart cities and improving customer satisfaction through intelligent trains using shared data. Railways provide the best value in terms of service quality and cost, handling large volumes efficiently and very safely. The railways respond flexibly to changing market demands and operational conditions helping to provide, irrespective of mode, seamless transit.

- *The future rail transport mode shall be customer driven.* It shall be available seven days a week and be reliable, resilient, safe and sustainable. The network capacity shall be optimized to increase freight and passengers' services. It shall rely on intelligent maintenance to improve performance, reduce the costs and business risks. It shall be based on a flexible, real-time intelligent traffic management and information to optimize operational performance and keep passengers informed. The rail transport system shall minimize carbon and noise emissions and be resilient to climate change. It shall attract the best talents (entrepreneurs and innovators).

- *For freight*, rail will increasingly replace road transport, especially for the transport of dangerous goods. Technical and operational interoperability on international rail freight corridors will substantially increase the competitiveness of rail as compared to other transport modes. Perceived nuisance factors such as noise and vibration will be limited to tolerable levels, thanks to technical innovations, e.g. composite brake blocs.

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On a more technical point of view, there are key innovation areas (mostly mentioned by ERRAC 2030 R&I priorities towards ERRAC 2050 Vision) that will give answer to the challenges of the future, contributing to a complete image of the sector.

- **Digitalisation:** A fully connected and integrated digital railway (system, sector and process) will be the basis of efficient asset management. The digital railway will drive the integration of the overall mobility digital eco-system for all transportation modes. Digital Asset Management will be the base for digital end-to-end mobility for passengers and freight, supported by a resilient and powerful telecommunication network.
- **Automation and Artificial Intelligence:** Real time management of the operation, along with new concepts such as virtual coupling and platooning, will support the increase of flexibility in operations. Autonomous trains and automated freight operation will bring additional predictability and versatility. All these elements together will support an increase of the capacity and resiliency of the system without major infrastructure investments. It will also lead to more end-user/citizen satisfaction from improved traffic management enabling better punctuality and comfort and more flexibility for real-time demand fulfilment.
- **Sustainable solutions:** Globally connected energy management systems will definitely be a step towards more sustainable mobility solutions. Holistic energy management systems will allow very efficient use of energy and the minimisation of energy losses. Societal demands will be covered by environmentally friendly solutions (e.g. alternative to diesel, reducing noise, vibration and emissions) and developing pro-active security systems in rail. In addition, green synergies with other transport modes, such as electric road vehicles, will decrease the global transport sector's footprint by improving energy recovery and energy-shared optimisation. Additionally, the initial integration with other transport modes within this shared energy system may open the door to further opportunities beyond the transport sector for the following years (e.g. targeting smart grids by 2040-2050).
- **Cost efficiency:** Digitalisation of engineering, operations and maintenance activities will reduce the overall cost of the system. For example, the digital twin of railways and virtual authorisation techniques will optimise 'time to market' for railway solutions. Widespread use of the digital twin, with BIM as a prerequisite, will facilitate multi-stakeholder sharing and delivery speed and quality, as well as sustained asset management monitoring on a life cycle basis.
- **Fast track to the Market:** In the current context it is essential that innovation is quickly deployed and implemented. More efficient bottom-up standardisation mechanisms and simplified regulations will support the implementation of innovations. Standardisation will be defined in a holistic way so to fit into the whole transport sector's needs and in collaboration with other modes, e.g. when tackling digitalisation standards. This includes new thinking for the design of business models.

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- **New mobility solutions:** As digitalisation and automation are developed and deployed, new opportunities for radical changes to the transport system appear, easing its transition from being an asset business to becoming a service business where the end-users/citizens do not own their mobility assets but pick conveniently from a portfolio of services, called "Mobility as a Service", designed around the most sustainable options for each use case or need.
- **Safety and security:** Rail is the safest mode of transport and provides maximum physical security with minimal adverse effects on free flow, and be resilient to cyber-attack
- **Rolling Stock and Infrastructure assets:** Faster and more efficient trains and high capacity freight vehicles. Rolling stock that meets customer needs is key to business success. Also, optimum life cycle cost infrastructure, supporting global corridors operating without border delays.
- Human Resources: Railway has organised, well-trained and professional workers. **The railway is regarded as an attractive industry in which to work and is a magnet for talent and innovation.**

4.1.6 Rail innovative technology scanning

This section includes a summary and a listing of the specific technologies or areas of technological development that, due to their nature will highly influence rail in the future.
The development and widespread deployment of a host of related technologies that will help rail reach its vision includes some that represent the evolution of current developments:

- **Digitalisation:** The instrumentation of assets, processes and personnel with powerful Information and Communications Technology (ICT) capabilities, able to sense, detect, process, receive, transmit and analyse digital information across secure, reliable and ubiquitous networks, making them all participants of global ''internet of things; Digital twin.

- **Automation** makes it possible to anticipate a network of intelligent vehicles that negotiate the efficient and reliable use of transport networks in an autonomous mode, either singly or linked to other vehicles (a train), according to demand, but under remote supervision. It is already applied in the operation of some of the most intensively used parts of the railway network and widely applied in aeronautics. Intelligent infrastructure facilitates this automation. This will include Advanced Interoperable Train Control systems, advanced Traffic Management (TMS), next Generation of Control-Command 4.0, intelligent and Autonomous Vehicles, automation of the Logistics Chain.

- *Distributed cognitive computing:* endowing machines with the ability to become aware of and understand their surroundings, to recognize patterns, to generate meaningful insights from large amounts of distributed data, and to learn; Machine learning

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- *Robotics:* endowing machines with the ability to perform goal-oriented tasks autonomously; Artificial intelligence – genetic algorithms, fuzzy logic, neural networks

- *Distributed immutable shared ledgers*: e.g. "blockchain" technology, allowing the secure recording of transactions without centralized control or coordination;
- *New "intelligent" materials* with self-healing properties and the ability to shape themselves in response to external stimuli. New materials validation, additive manufacturing and manufacturing techniques for maintenance.

- *Energy and traction.* Alternative propulsion concepts (fuel cells, hybrid power, discontinuous electrification), smart grids, dynamic wireless power transfer. New traction drives based on the SiC technology is one of the major cutting edge developments of the cooperative Shift2Rail program.
- *Infrastructure:* Low carbon construction, asset monitoring based on sensors, maintenance 4.0, modular design, smart buildings. Intelligent Assets Lifecycle Management: Whole-Life Asset Approach: Digitalization of the maintenance system, prognosis and health assessment at system level, specific technologies for maintenance execution, new construction methods

- *Operation:* Dynamic traffic management, ERTMS, Europe's GNSS Galileo applications
- *New transport technologies* such as delivery drones or pods (like Autonomous Nano Transport Systems, known as 'ANTS'), or the adaptation of older technologies, as is the case with Hyperloop, Maglev and freight airships and blimps, have the potential to bring fundamental change to mobility provision. The railways have experience and skills that will be of value to other guided systems, as well as to those dependent on the management of interfaces between systems, as with autonomous and connected vehicles.

Transformative future research and scientific advancement have the possibility to change technology dramatically. Long-term progress is guided by the emergence of technologies which have not yet been imagined or realized. By packaging these technologies into new components, systems, processes, products, and services, the rail sector will perform a comprehensive industrial transformation, introducing far-reaching innovations in the way it operates and services society.

Capabilities

To take advantages of the opportunities and vision for the rail sector, the Shift2Rail Joint Undertaking has identified **12 Innovation Capabilities** that will enable the sector to produce value-adding products and services.
These capabilities have been the basis of the Shift2Rail programme and are a valuable tool for the definition of the whole rail sector capabilities.

- Innovation capability #1 – Automated train operation: Trains are able to operate themselves and run closer together based on an automated train operation system, boosting the capacity significantly on existing lines. Rail operations are partly or fully automated.

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- Innovation capability #2 – Mobility as a Service: Customer demand-driven services lead the railways to provide excellent service within the overall mobility chain. All customers and potential customers are connected to mobility services. Services are seamless

- Innovation capability #3 – Logistics on demand: Logistics services are driven by customer demand, with freight moved reliably in flexible units designed to carry out various loads. The rail system is fully integrated with the multimodal logistic chain.

- Innovation capability #4 – More value from data: Collection, analysis, interpretation and prediction are automated to provide consistent up-to-date information supporting fast, well-informed decisions and business benefits. This is achieved through robust, resilient and secure information architecture and governance structure.

- Innovation capability #5 – Optimum energy use: The introduction of new technologies and methods as supporting tools enable reduced and optimized demand-led energy use and energy efficiency.

- Innovation capability #6- Service timed to the second: Situational awareness, where each train's location is known at all times and in real-time, supports service operation timed to second.

- Innovation capability #7 – Low-cost railway: It covers notably European simplified train certification processes and validation techniques, the use of lightweight materials to reduce maintenance cost and energy consumption.

- Innovation capacity #8 – Guaranteed asset health and availability: Optimised maintenance keeps the railway continuously open, fostering minimal disruption to train services.

- Innovation capacity #9 – Intelligent trains: Intelligent trains are aware of themselves, their passengers/loads, and their surroundings. They also intelligently feed information of infrastructure to support preventive maintenance.

- Innovation capability #10 – Stations and "smart" city mobility: New and modernised station designs provide easy access and seamless interchange between the transport modes.

- Innovation capability #11 – Environmental and social sustainability: Railways continue to deliver sustainable transport solutions as overall travel demand intensifies. Inclusive and easy access is available for all citizens to railway facilities, products and services.

- Innovation capability #12 – Rapid and reliable R&I delivery: The rapid integration of technology into the railways moves barriers to the adoption of new technologies and decreases time to market.

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UNIFE has defined nine Key Enablers, which are the nine areas of priority for European rail research and innovation identified by the industry.

- *Key Enabler n°1: Automated rail transport:* One of the main characteristics of future rail transport is increased automation. This key enabler aims at improving the efficiency and effectiveness of the overall rail transport system by further developing automation technologies.

- *Key Enabler n°2: Mobility as a seamless service:* This key enabler aims at providing customers (passenger and freight) with seamless, personalised, efficient and cost-effective door to door journeys (with rail as its backbone), minimising the environmental impact.

- *Key Enabler n°3: Digitalisation:* The main objective of this key enabler is to support a fast and widespread deployment of digital technologies across the railway system.

- *Key Enabler n°4: Towards an efficient Zero Emission Railway:* Rail transport should stay the greenest mode of transport. Decreasing energy consumption in all railway applications is a general objective in order to keep rail as the most environmentally friendly transport mode.

- *Key Enabler n°5: Maintenance of the future:* The objective is to increase the efficiency of the required maintenance actions for both infrastructure and rolling stock and support a seamless train operation with zero avoidable failures.

- *Key Enabler n°6: Enhancing the security and the protection of the rail system:* Innovative solutions can be used to prevent or limit terrorism or violence and increase the level of confidence. Ensuring protection against cyber-attacks will also be a key achievement to a successful advanced mobility implementation.

- *Key Enabler n°7: Optimised infrastructure:* The objectives of this key enabler concentrate around the full integration of rail transport in the multi-modal transport vision, the reduction of investment and operational cost and the increase of capacity in the urban area.

- *Key Enabler n°8: Digitisation of the supply chain:* Digitisation is one of the key emerging industrial revolutions. It shall bring substantial added value to the whole rail supply chain.

- *Key Enabler n°9: New certification framework:* A new certification framework needs to be created.

4.1.7 How to deliver the vision

This section aims at describing the specific research elements that will need to be developed in

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order to reach the vision.

Innovations to deliver the vision.
The following technological developments are seen as key for delivering the vision and are deeply described in the documents.

Digital Technologies (e.g. Big Data, AI, General Intelligence)
Autonomous train operations and automated and connected systems
Intelligent assets lifecycle management: whole-life asset approach and maintenance of the future
Protecting the environment and the energy supply
Ensuring safety and security.
Digital rail industry supply chain management

Requirements for Delivery:
a) A seamless European research and innovation system that assures continuity
b) Strong cooperation between rail stakeholders
c) The integration of experts from other scientific disciplines and from academia, bringing valuable knowledge from other sectors
d) Education and training – including partnerships for innovation skills development and jobs, knowledge transfer and lifelong learning
e) Effective cooperation with other modes of transport to provide a connected, efficient, and reliable European transport system.
f) Financial schemes: It will also require significantly greater levels of financial investment in RDI than has been made available to date. Market forces alone are insufficient to provide the necessary level of investment. This market failure reflects structural challenges and the diversity of technologies within the railway sector, their long life-cycles and their technical interfaces, all of which generate significant risks at different levels of the railway transport system and discourage investments from financial markets. Therefore, public funding both at European and national levels remains vital.
f) Policy: Delivery will also need to be underpinned by an appropriate, efficient and effective policy and regulatory framework. Public authorities should also be involved in the process, and it is necessary to create a good partnership between all stakeholders.

Mechanisms for an effective delivery framework:

- Funding: Substantially increase the European funding instruments for RDI, following the European rail Public-Private-Partnership Shift2Rail JU. Also, the future European railway system will be all the more successful if it can rely on attracting sources of funding that do not only depend on government intervention.
- Put in place simple and effective mechanisms—accepted by all stakeholders—to coordinate shared objectives for RDI projects at private, European, national, and regional levels.

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- Enable and incentivise a much shorter time to market from initial research to commercialization. Standards for services and systems, enhancing interoperability and securing an efficient supply chain.
- Create new dynamics in regulations to allow innovative technologies to be adopted more quickly.
- Put in place the mechanisms to bring innovation to the market, accompanied by the phasing out of obsolete technologies to accelerate the time to market to meet overall societal needs.
- Access to test facilities, including increased use of virtual testing, to prove the business value of new designs.
- Access to industrial expertise, essential to evolution, based on manufacturers and other suppliers focusing on the business needs of the railways.
- Standards for services and systems – For the shared network, where various operators use the same infrastructure, applying the same or perfectly interfacing processes is a key prerequisite for a safe and reliable operation, not only within but also beyond Europe. Having a suite of well-prepared standards incentivises the design of components - improving operational excellence, maintenance logistics, enabling scale-effects and above all, providing reliable and attractive to the customer and end-user.

4.1.7.1 The Shift2Rail specific technical approach:

The Shift2Rail Joint Undertaking is making a decisive contribution to delivering the vision expressed through the capabilities exposed in the previous sections. S2R is delivering many benefits including a reduction in pollution, a more efficient, affordable, sustainable and better performing rail system for the tax income spent funding the public transport systems, more job opportunities due to the requirement of private and public investments and an increases in efficiency and capacity. Next to that, S2R has a system approach. This means the rail sector shall be integrated into the other modal networks (airports, ports, metro and bus stations) in terms of design maintenance and delivery and safe operations.
The Shift2Rail research and innovation activities range from fundamental research (low TRL) to demonstration activities (high TRL) and are structured around five Innovation Programmes and cross-cutting activities.

The Shift2Rail Innovation Programmes:

- IP1 – Cost-efficient and reliable trains, including high capacity trains and high-speed trains
- IP2 – Advanced traffic management and control systems
- IP3 – Cost-efficient, sustainable and reliable high capacity infrastructure
- IP4 – IT Solutions for attractive railway services
- IP5 – Technologies for sustainable and attractive European rail freight

Additional research and technological developments of S2R are;

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- Dedicated research projects on the development of specific technologies and concepts to fill the gaps in innovative technologies, and in business, organisational and logistic solutions,

- Strategic studies, such as for instance deriving the future demand for rail services from long-term trends,

- Projects addressing cross-cutting activities supporting the successful take-up of technology innovations (such as long-term needs and social-economics research, smart materials and processes, system integration, safety and interoperability, energy and sustainability, human capital).

The demonstration of technical achievements, up to TRL 7, is based on a three-fold architecture made of:

- **Technology demonstrators**: Development or adoption of innovative technologies and models within the rail sub-systems.
- **Integrated technology demonstrators**: Combinations of components and sub-systems already verified and validated within the technology demonstrators.
- **System platform demonstrators** that are conceived to stimulate and virtually test the interaction and impact of the various innovative systems resulting from the Shift2Rail activities.

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4.2 Rail Stakeholders

The second pillar of mapping rail innovative research consists in the understanding of the vision that the sector has of itself and the **trends and challenges of rail research and innovation** from the perspective of different rail stakeholders. This analysis helps to monitor needs and wishes, threats and opportunities**,** as well as providing very useful information to **structure interactions** that may lead to networking, cross-fertilization, and the kick-starting of new ideas and concepts for the railway of the future. The results as a whole will serve to **inform tasks 1.2 and 1.3 of TER4RAIL**, where further stages of the Rail Innovative Research Observatory are taking place.

This analysis has been accomplished through an online survey addressed to rail stakeholders, a panel discussion maintained during the Plenary of the European Technology Platform ERRAC, hold on the 21st of March 2019, dealing with the same topics as contained at the survey, and complemented through specific interviews with key associations and bodies representing railway actors.

4.2.1 Questionnaire

A questionnaire on rail research and innovation addressed to rail stakeholders has been elaborated gathering questions grouped in the following five categories:

1. Background
2. Organisation of Research and Innovation (R&I) inside the entity
3. Relationship with other stakeholders
4. Relationship with other sectors
5. Disruptive technologies and innovations

The questionnaire can be consulted in the Appendix 5.2. In order to maximize the outreach, ease the participation and facilitate the analysis of results, an electronic version of the questionnaire has been created using the on-line tool Survey Monkey.

A first joint effort was done by partners from Task 1.1 in order to elaborate a list of the most relevant rail stakeholders to be approached to answer the questionnaire. The list was specifically developed to identify agents from the whole value chain that can provide a broad vision from different points of view of the rail R&I environment. Partners from the major rail associations (UIC, UNIFE, UITP, NEWOPERA and EURNEX) participated in this exercise, so the selection of entities and contacts was representative and adequate to develop the rest of the activities of this task. This exercise was done with the objective to guarantee a minimum number of answers representing different typologies of actors of the railway sector (i.e. mainline railway operator / infrastructure manager; urban operator; supplier; university; research centre) and was complemented with broad distribution of the questionnaire through newsletters, social media, work groups and associations.

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The final on-line version of the questionnaire was available by 26th of February. Answers were collected during six weeks, performing continuously actions for the promotion of the survey, and being the deadline for responses on the 5th of April 2019. A graphic representation of the volume of responses over the weeks can be seen below:

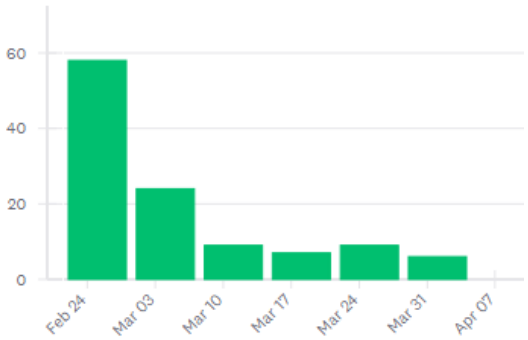

Figure 3: Volume of responses per week

These responses correspond to different actors of the railway sector, distributed as follows:

Type of entity	Received responses		Completed responses	
	#	%	#	%
Railway Operator/ Infrastructure Manager	9	8%	3	7%
Supplier	35	30%	10	22%
University	31	27%	15	32%
Research Center	19	17%	7	15%
Other	21	18%	11	24%

Table 2: On-line questionnaire response rate per type of entity

A total of 115 responses were gathered, out of which 46 can be considered as good ones valid for the analysis (40%). The rest have been excluded for being empty, having fulfilled only the name and type of entity in most cases.

The information contained below responds to the content provided by these 46 respondents. It is important to bear in mind that the use of these results is to provide orientation and indications for further stages of TER4RAIL WP1. The questionnaire was designed keeping this in mind, with non-compulsory open questions that give freedom to the respondent to express herself/himself. This design provides rich qualitative data and the opportunity to gain insights on a variety of opinions around rail research and innovation. It is therefore really useful for further activities under TER4RAIL WP1, but does not provide statistical significance.

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4.2.1.1 Organisation of Research and Innovation (R&I) inside the entity

37 out of 45 respondents to this question (82%) work at organisations with a Research and Innovation Strategy, and 27 out of 38 declare to have implemented the results of R&I activities to develop a new/improved service or product, providing examples such as:

- Hi-tech spin-offs; start-up company; join ventures to go to the market with new technology
- Creation of simulation tools; applications; algorithms; new equipment
- Direct use by clients; direct implementation in the day to day operation (immediately if not affecting security and safety); new technologies in own services; implementation in parts and components of vehicles
- Patents and software; pilots
- Improved procedures; new technologies; processes optimization
- Collaboration with industrial companies

Most of the respondents declare to use different types of funding sources for their research and innovation activities, as shown in the graphic below. Only 6 declare to use only one type of financing, being mainly associations, clusters or institutions.

National / Regional Public Funding Mechanisms are the most common ones among the respondents, being used by 39 out of 46. European Public Funding (35 out of 46) and Own Funding (27 out of 46) are also explored by more than half of the respondents. Private capital is used by 41% of them. An additional source of funding has been mentioned: prizes.

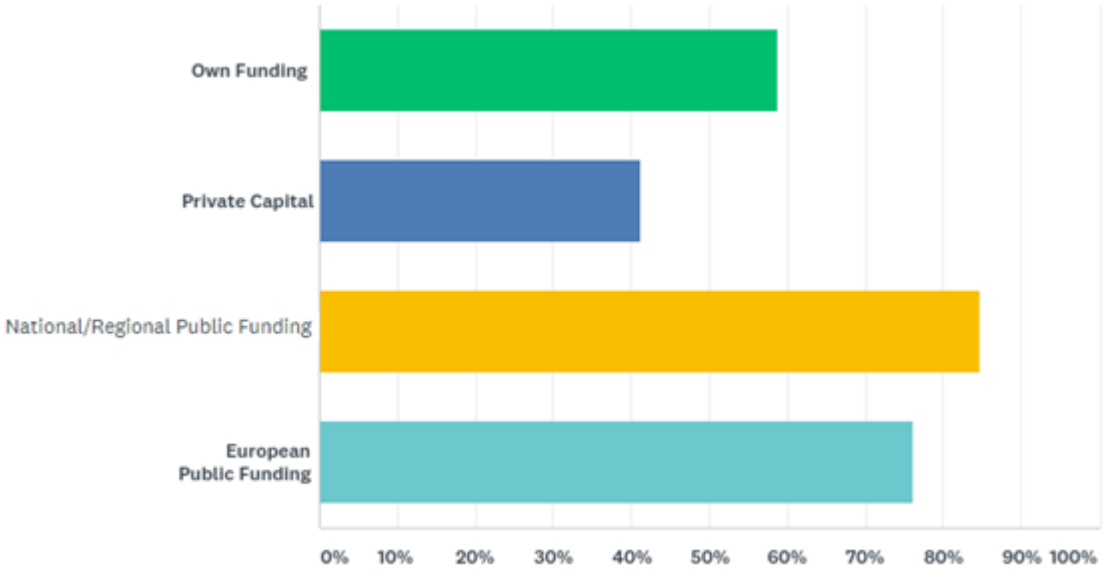

Figure 4: Answers to Q5 "When performing R&I activities, what type of funding source does your organisation use?"

Respondents were invited to write down the specific programmes and funding mechanisms that they have used when selecting European, National or Regional Public Funding. An aggregated list

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of the answers provided is presented below.

EUROPEAN PUBLIC FUNDING

- Shift2Rail
- European Framework Programmes FP4-FP7
- H2020
- CEF-Funding
- European Investment Bank
- LIFE & LIFE +
- CEDR Transnational Research Programme (TRP)
- European Institute of Innovation & Technology (EIT)
- ERA-NET+
- Fast Track to Innovation - FTI
- Interreg
- Interreg Alpine Space
- Interreg Central Europe
- Euratom
- COST, European Cooperation in Science and Technology
- Employment Policies
- European Regional Development Fund - ERDF
- Marie Curie
- EUREKA
- UIA - Urban Innovate Actions

NATIONAL PUBLIC FUNDING

AT - Austria Research Promotion Agency (FFG) - Mobilität der Zukunft
CZ - Czech Science Foundation
CZ - Ministry of Education
CZ - OPPIK – Operation programme for Business and Innovation
CZ - Technology Agency of the Czech Republic (TA CR)
DE - German national funding from Transport ministry
ES - Ministerio Industria: AEI (Agrupaciones Empresariales Innovadoras); AVANZA I+D
ES - CDTI: INTERCONNECTA, CIEN, Proyectos de Investigación y Desarrollo (PID), CENIT
ES - Ministry of Science, Innovation and Universities: National Plan for RDI. INNPACTO, RETOS COLABORACIÓN, RETOS PROYECTOS IDi.
ES - TrenLab
NL - National subsidies for science and technology eg NWO
NL - WBSO (R&D tax credit) of the Ministry of Economic Affairs and Climate Policy
SI - KEGA Grants - Ministry of Education, Science, Research and Sport of the Slovak Republic
SI - National Research Agency
SI - Scientific Grant Agency VEGA
SI - Slovak Research and Development Agency (APVV)
UK - Economic and Social Research Council (ESCRC)
UK - Engineering and Physical Sciences Research Council (EPSRC)
UK - Innovate UK
UK - RSSB

REGIONAL PUBLIC FUNDING

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DE - Local Bavarian funding
ES - ACCIÓ-Generalitat de Catalunya
ES - Agencia Gallega de Innovación: Conecta PEME, Industria 4.0., InnovaPEME
ES - Agencia Valenciana de la Innovación (AVI)
ES - Comunidad de Madrid: Programa 'Impulsando Talento' ; Proyectos Sinérgicos
ES - CONECTAPEME (Xunta de Galicia)
ES - Departamento de Investigación del Gobierno vasco
ES - Generalitat Valenciana (proyectos Prometeo para grupos de investigación de excelencia)
ES - Instituto Madrileño de Desarrollo (IMADE) - PIE: Plan de Innovación Empresarial
ES - IVACE: Instituto Valenciano de Competitividad Empresarial

In relation to their involvement in Shift2Rail, 65% of them declare to have participated in the initiative, either at the Open Calls (60%), as Associated Member (30%), supporting the participation of other entities (2 entities); as linked third party (1 entity) or as observer (1 entity).

The answers provided in relation to the percentage of R&I activities performed in collaboration with other entities or individually are very diverse, ranging from 5% to 100% for collaborative R&I activities and from 0% to 100% for individual ones, depending on the respondent. As such this does not permit to conclusions. The average percentage provided for the collaboration with other partners is slightly higher (60,88% compared to 48,91%), but both figures are very similar.

Looking at the **drivers** that motivate the undertaking of R&I actions, the top three most important ones, according to the responses, are:

- Making use of ideas or scientific / technological novelties
- Energy Efficiency and sustainability
- Making use of an idea generated inside the company

The ones considered less relevant by the respondents are:

- Compliance with regulation
- Enter new markets
- Reduce labour costs per unit output

In relation to the **hampering factors** that affect R&I action or influence a decision not to innovate, the top three most important ones, according to the responses, are:

- Lack of funds from outside
- Lack of funds within your organisation or group
- Perception of excessive economic risk

The ones considered less relevant by the respondents are:

- No need due to prior innovations
- Need to meet regulations
- Lack of information on technology

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When asked on the **measures undertaken** by the organisations where the respondents work **to overcome R&I barriers**, the following answers, grouped per thematic and presented in random order, were provided:

Collaboration

- Partnerships: Technological ones; with customers; with other companies/ technological centres
- Seek participation in collaborative research initiatives, European Programmes
- Workshops and events with innovators / clients; present ideas in a wide range of forums
- Research for a known client on a known problem
- Check what the demand is and what the general ideas are concerning priorities by looking at European Programmes

Funding

- Looking for financial resources from European Funds, to minimize problems coming from lack of national and/or own funding
- Searching other ways of getting funds: Negotiate additional funding; European Investment Bank (EIB)
- Convincing technological partners to be also investors (e.g. start-up)
- Use of National Public Funds
- Members fee to maintain a capital for taking some risks and secure highly specialized human capital

Strategy

- Change the development strategy from customer-based to market-based
- Focus on problems to get innovative solutions. Open innovation
- Implement a technology watch system
- SWOT analysis
- Using always the same methodology

Other

- Talent retention
- Educate students to be good and qualified engineers (university)
- Cutting edge devices

Respondents from **universities** answering the questionnaire were asked to indicate the number of **Railway Doctoral Thesis** undertaken at their university during the last 10 years and the themes addressed in them. The answers provided to these questions are:

- Universitat Politècnica de València (ES): 20 thesis
- Universidad Politecnica de Madrid (ES): more than 40 thesis. Themes: dynamic, transport policy, railway infrastructure, energy, signalling, maintenance
- KTH (SE): ca. 20 thesis. Themes: mechanical, civil and electrical engineering

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- University of Pardubice (CZ): approx. 30 thesis. Themes: railway operation, control, construction of railways vehicle, infrastructure, IT systems
- University of Huddersfield (UK): approximately 10.
- Politecnico di Milano (IT): around 15-20 Doctoral Thesis in the field of Railway Engineering. Themes: Mechanical Engineering, Electrical Engineering, Automation & Control Engineering
- University of Applied Sciences (AT): a Doctoral Thesis is not possible
- Institute for Railway Engineering and Transport Economy TU Graz (AT): 10 thesis. Themes: civil engineering topics, mainly railway track optimization
- Brno University of Technology (CZ): 5 thesis. Themes: Railway infrastructure
- University of the Basque Country UPV/EHU, Bilbao (ES): 8 thesis. Themes: Railway Dynamics, Track dynamics, Noise Rail Corrugation, Structural optimization, Wheel-Rail contact
- University of Aberdeen (UK): currently finalising a thesis on interfaces of urban underground metros and their environment. Themes: Civil engineering; law; property; urban and transport planning; urban underground space
- Edinburgh Napier University (IE): No information
- Newcastle University (UK): hundreds of theses in the whole University. Themes: just to mention some, vehicle design, crashworthiness, city logistics, energy storage systems, materials selection, subway climate analysis, rail freight business models, dead zones in electrical distribution, driver behaviour at stations, and many many more

4.2.1.2 Relationship with other stakeholders

This block of questions aims at exploring the way in which railway stakeholders relate with other entities from the railway sector and with other sectors on research and innovation issues.
When asked on the external **collaboration partners** with whom the organisation of the respondent collaborates on research and innovation, the main types of entities mentioned are universities, research institutes and railway operators. This question provided a pre-defined list of options allowing multiple choices and giving the opportunity to add more categories by clicking "other". 40 respondents provided answers to this question, being the results as shown in Figure 5 below:

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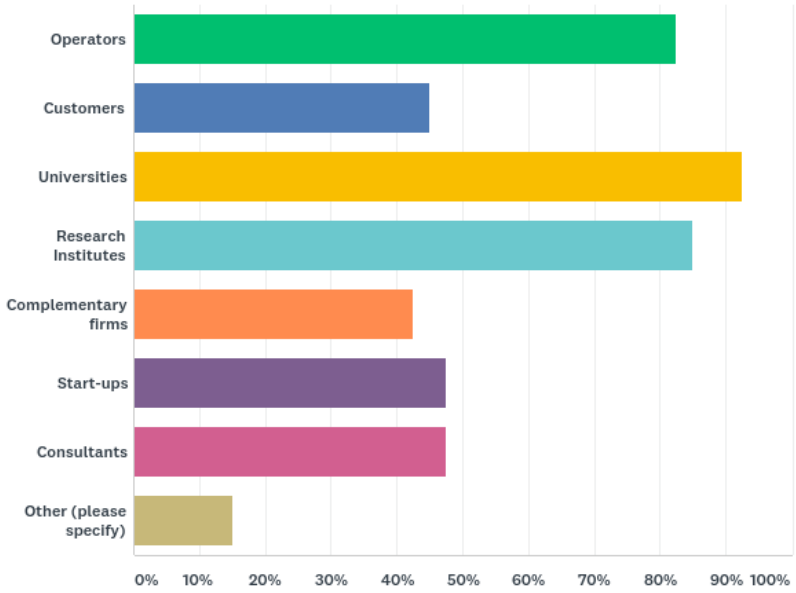

Figure 5: Answers to Q17 "From the following list of possible external collaboration partners, please select the ones with whom your organisation collaborates on research and innovation"

The category "other" was selected by 6 respondents, who specified:

- Vehicle manufacturers
- Manufacturers, Infrastructure managers
- Industry and contractors
- Infrastructure managers
- Clusters
- Suppliers

Going through the **type of collaboration** established by the respondent's organisation with other stakeholders on research and innovation, most of them indicated collaboration through public research instruments (selected by 85% of the persons answering); and through private contracts (e.g. subcontracting, joint venture, etc.) (77.5%). The options selected by a fewer number of respondents were "open innovation instruments, such as hackathons, incubators or prizes" (selected by 30% of the persons answering), and "acquiring a smaller firm, available licenses, patents, etc." (17.5%). A graphic representation of the answers is shown in Figure 6 below.

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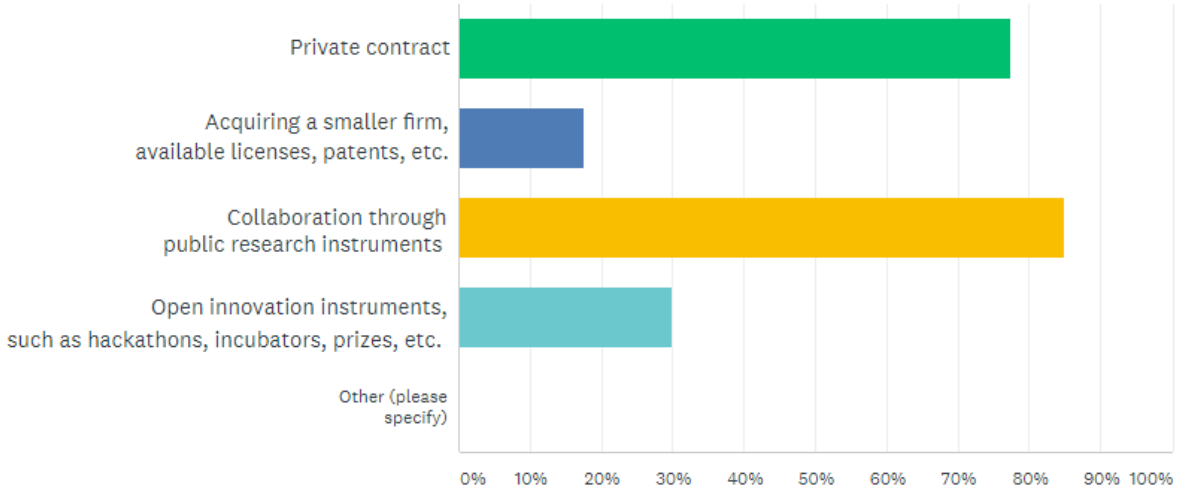

Figure 6: Answers to Q18 "What type of collaboration for R&I does your organisation establish with other stakeholders?"

This question provided a pre-defined list of options allowing multiple choices and giving the opportunity to add more categories by clicking "other". 40 respondents provided answers to this question; none of them selected "other" or provided further categories.

A low number of respondents, only 9, have chosen just one type of collaboration: 7 only collaborate through public research instruments and 2 only through private contracting. Most of them declare to use several ways of collaboration, having selected 77.5% (31 out of 40) more than one type.

When selecting several responses, they were asked to indicate which one of the type of collaboration is the most commonly used by their organisation. 8 of them selected collaboration through public research instruments; 4 of them private contracts; 2 indicated the acquisition of a smaller firm; 1 open innovation; and 1 indicated that all the options chosen were balanced and had the same importance.

Only two respondents provided their opinion on the advantages and disadvantages of some of the types of collaboration indicated. In their opinion, flexibility is the main advantage of the use of private contract and non-disclosure agreements its disadvantage. Regarding collaboration through public research instruments, the availability of funding for all partners is considered an advantage, while the dictation of research areas a disadvantage.

Asked on the **entities followed as a reference on R&I issues**, Shift2Rail (30), ERRAC (22) and UNIFE (21) were the entities selected by most of the 35 respondents that provided an answer to this question; followed by UIC (17), ERA (15) and DG MOVE (15) as shown in Figure 7.

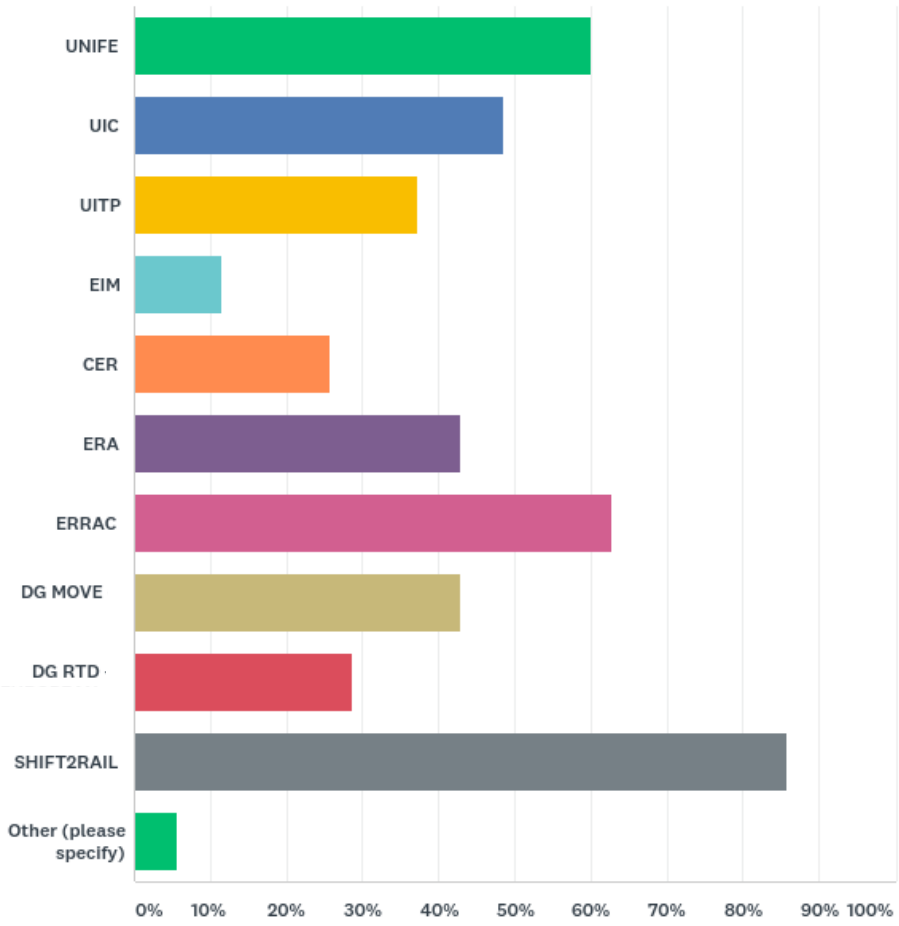

Figure 7: Answers to Q20 "Does your organisation use any of the following entities as a reference in relation to R&I issues?"

It is important to mention that Shift2Rail is also recognised as a reference on R&I issues by entities that declare of having no participation in it (is a reference for 30 entities, despite only 27 declared to have participated). As "other", the Spanish Railway Industry Association MAFEX and the Latin-American Association of Metros and Undergrounds ALAMYS were mentioned.

4.2.1.3 Relationship with other sectors

A big majority of the respondents (36 out of 41) declare that they **cooperate with other sectors**, different to rail, on R&I rail-related issues. Only 5 declare having no cooperation with other sectors.

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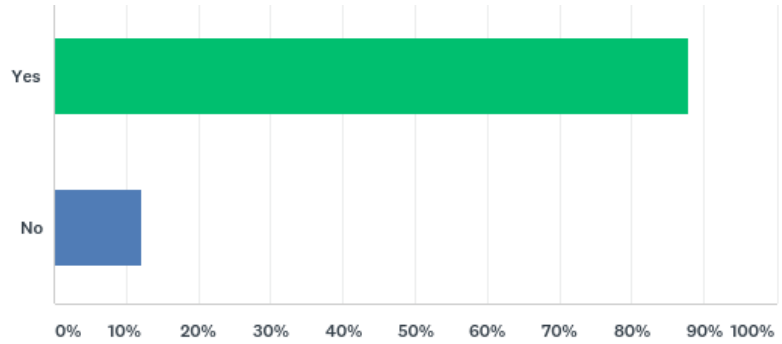

Figure 8: Answers to Q21 "Does your organisation cooperate with other sectors, different to rail, on R&I rail related issues?"

Respondents were invited to indicate the non-rail sectors with whom they are currently cooperating. This was an open question answered by 31 respondents. Their answers have been grouped and the sectors mentioned are represented at the graphic below.

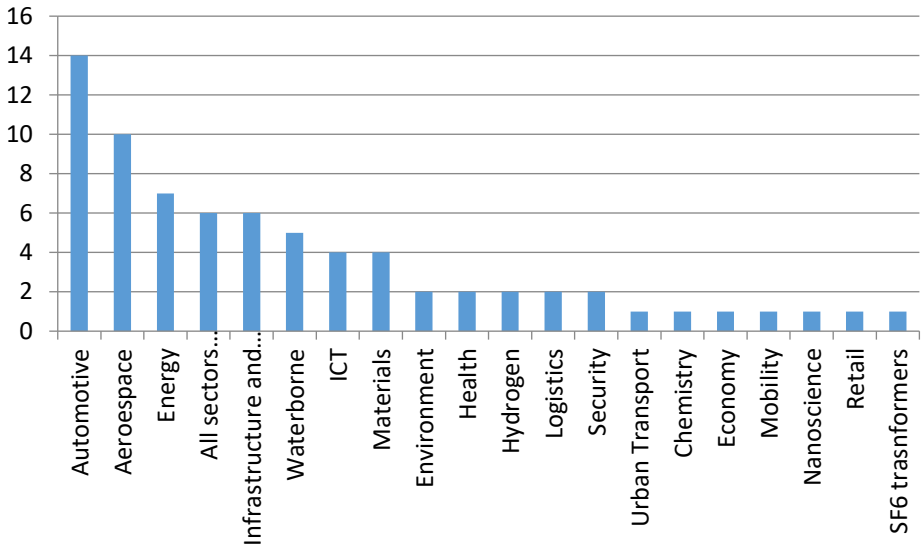

Figure 9: Non-rail sectors with whom survey respondents cooperate on rail R&I

Automotive is the sector that has been mentioned more times, being present in 14 out of the 31 responses (e.g. truck, road, road authorities, automotive, automobile…). It is followed by aerospace, mentioned 10 times, (e.g. aviation, airport, aerospace, aeronautic…); energy, mentioned 7 times; all sectors / all engineering fields and infrastructure and construction; mentioned 6 times each; and waterborne, mentioned 5 times (e.g. harbour, inland waterways, maritime…).

Other sectors mentioned, but with less frequency are: ICT (mentioned 4 times); materials (4); environment (2); health (2); hydrogen (2); logistics (2); security (2); urban transport (1); chemistry (1); economy (1); mobility (1); nanoscience (1); retail (1); SF6 trasnformers (1); smart grids (1).
When asked on **the way in which their organisation relates with other sectors**, a pre-defined list

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of options allowing multiple choices was provided, and these were the answer given by the 34 respondents who answer the question.

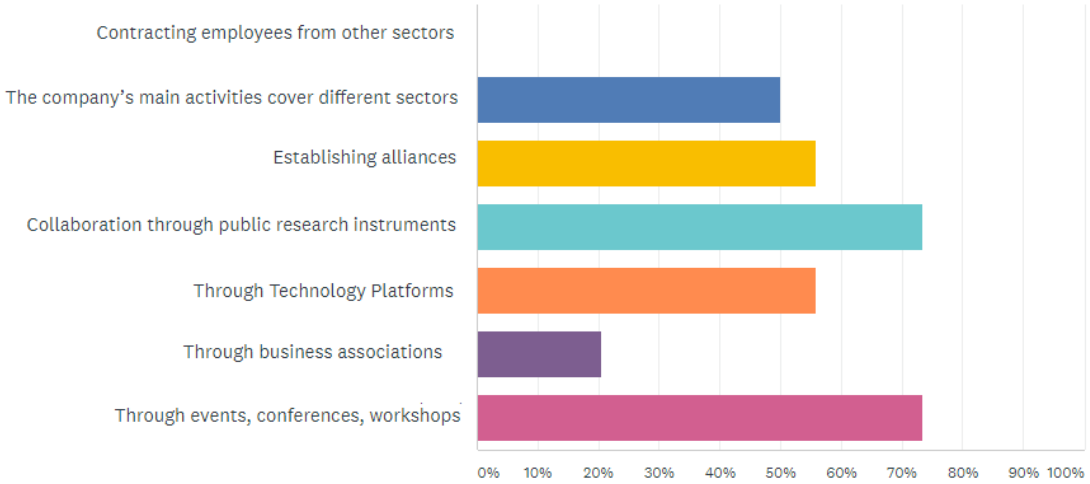

Figure 10: Answers to Q22 "How does you organisation relate with other sectors on R&I activities?"

Collaboration through public research instruments and the use of events, conference and workshops (with 25 answers out of 31 each) were the most common ways. The establishment of alliances and technology platforms (with 19 answers out of 31 each) are also very commonly used.

This question included the possibility to write other ways, provide comments or give examples. Only three respondents used this possibility, reinforcing two of them the role of technology platforms (especially multidisciplinary ones), and one pointing at TRA as a good example fostering collaboration between different sectors.

Asked on the **sectors / stakeholders with whom they would like to have cooperation** on R&I rail issues, despite their organisation does not currently cooperate with, the answers provided are:

- In main cases, railways are understood as cross activity for the industrial sector, applying specific products
- Space and automation
- Enhanced cooperation with the industry
- Road
- Robotics
- Operator and infrastructure companies, Material providers, Engineering companies

When asked on **examples of good practices related to networking / cross-fertilization** that have proved to be very useful for the relationship with other stakeholders (rail or non-rail) on R&I issues, these are the ones mentioned:

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- Shift2Rail and Shift2Rail events as a good opportunity to know other players.
- Technology platforms
- Win-win agreements
- Memorandum of undertaking with associations or particular entities scheduled in 3-5 years
- Cross-fertilization and networking
- TRA
- Forums like Logistics Research Austria
- Coordination and Support Actions on Transversal Cooperation

4.2.1.4 Disruptive technologies and innovations

Participants were asked to write down the three most promising technologies or innovations that have the potential to transform the rail sector…

… in the next 5 years

Digitalisation	10
Materials	8
5G	5
Automation	5
Batteries	5
Big Data	5
Energy	5
Condition based maintenance	4
Artificial Intelligence	3
Building Information Modelling - BIM	3
Automatic Train Operation	2
Augmented Reality	2
Block Chain	2
Communications	2
Internet of Things	2
Monitoring technology and sensors	2
Power sources	2
Signalling technology	2

Table 3: Most promising technologies or innovations – next 5 years

…in the coming decades

Digital transformation	10
Materials	7
Artificial Intelligence	6
Automation	5
Autonomous mobility	5
Power sources	5
Hyperloop	4
Big data	3
Energy	3
5G Wireless connectivity	2
Condition based monitoring & predictive maintenance	2
Environment necessities	2
Internet of Things	2
Nanotechnology	2

Table 4: Most promising technologies or innovations – coming decades

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A graphical representation through a word cloud of the previous two tables is the following:

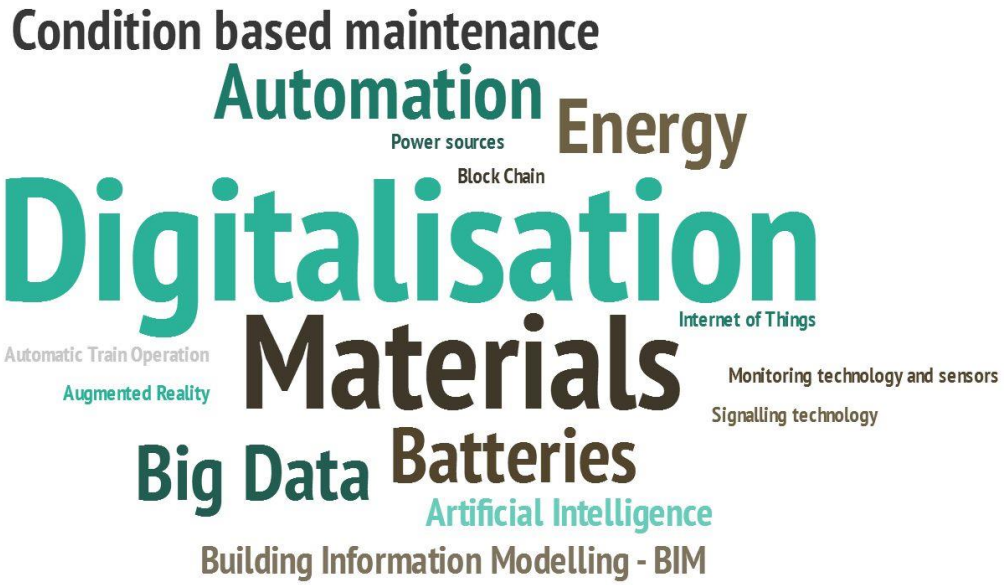

Figure 11. Most promising technologies or innovations that have the potential to transform the rail sector in the next 5 years

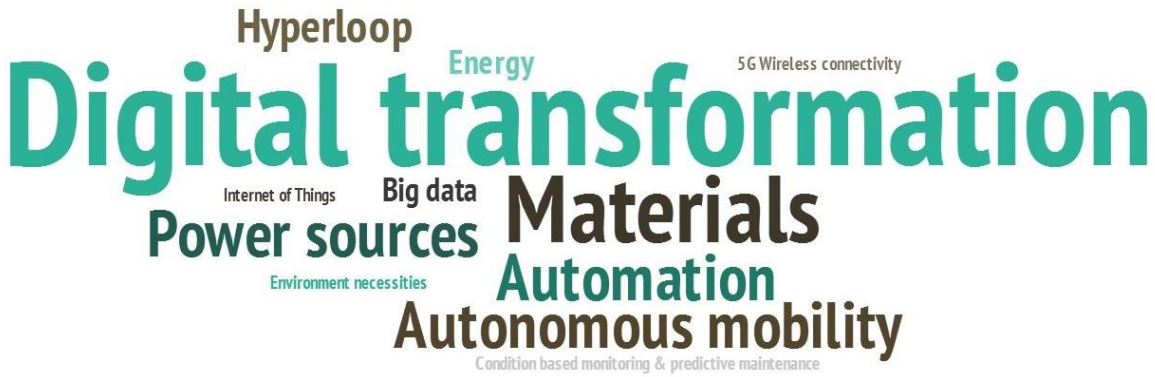

Figure 12. Most promising technologies or innovations that have the potential to transform the rail sector in the coming decades

Other technologies and innovations that have been mentioned, but only once, when asked in the next five years are: Additive manufacturing; Advance ticketing; computing speed; Cooperative/collaborative learning/action; Cybersecurity; GNSS technology; High Speed; Hydrogen; Internet of Trains; Interoperability; LIFY; MaaS; Machine learning; Mechatronics; modern ticketing and information systems; Nanotechnology; new services; On board internet; personal account based, paperless ticketing; Robotics; Sustainable solutions; Tube transportation (Hyperloop); User-centric and social approach of rail.

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Other technologies and innovations that have been mentioned, but only once, when asked in the coming decade are: Additive Manufacturing; ATO; Batteries; Cyber security; Communications; Cooperative user integration; Electric and automatic people movers (incl. drones); High speed rail; Machine learning; Mobility as a service; New electric motors; Operations; Passenger well-being monitoring; Robotics; Seamless data transfer; Self healing and self adjustable technologies.

When asked on the sources of information used to detect innovations, is remarkable high the value given to the item "own employees" (75.76% of the respondents consider this aspect as very relevant). On a second level, "technology monitoring" (58.82%), "through associations, networks" (55.88%) and "use of scientific literature" (54.55%) can be found.
On the other hand, the "use of patent database" is considered the less relevant factor for detecting innovations (43.75% of respondents consider that it has very low relevance).

When asked on the question on how the organisations where the respondent works are dealing with emerging innovative technologies and how are they **being prepared for the future**, a wide range of answers was obtained.

- Several answers mentioned the constant use of monitoring technologies, as well as performing research. Through scientific literature has been mentioned once.
- Acquiring knowledge through conferences and cross-fertilization events in order to advance the future was also indicated by several respondents. Participation at workgroups and associations was also mentioned.
- Some answers mentioned human resources: specific team inside the company implementing new technologies; R&I department; contact with experts; thought leaders for collaboration.
- Regarding the process followed, one of the respondents indicated that it is a slow process. Other indicated that it is a continuous learning process or need to be in constant touch with innovative technologies. Another one indicated that they avoid 'big bangs': first technology monitoring, then research projects, proofs of concept and, finally, if possible, large corporate projects.
- A couple indicated that innovation is part of their core, as their organisations are already part of an emerging market or are technological partners for innovation.

When asked how their companies are **dealing with digitalisation**, and their specific initiatives or plans, a summary of the answers collected is provided below:

- The implementation of a Digitalisation Strategy, plan or specific institutional approach has been mentioned by 6 out of 20 respondents.
- Partnerships and the creation of specific teams are also mentioned once each.
- Regarding the process followed, two said it was ongoing and continuous; one indicated is slow; and three more that they were already digitalised or had been born digital. One respondent

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indicated that their organisation was prepared to tackle digitalisation and another one that they were not really prepared.

- Looking at specific themes, these are the ones mentioned: new signalling systems; condition-based maintenance; "digital train": platform for connected trains, connected assets and improved cost-efficient strategies of both maintenance and operation; "digital station"; BIM; management systems; Conditioned Based Maintenance; Freight Digitalization; Asset Management; information technology; virtual reality of vehicles for simulated testing; cyber security; design and manufacturing processes.

Finally, when asked on **examples of good practices** related to the challenges set by new innovative technologies on rail R&I issues, the following answers were collected:

- Programmes promoting start-ups from research community activities
- Start with a smaller initiative like a proof of concept for 1-2 use cases before jumping into a large 'big bang' that transforms the company
- Make sure knowledge is kept inside the company
- Promote or at least to be ready to participate in research projects which are aligned own needs
- Projects dealing with new technologies. Examples: VAST - – Virtual Airspace and Tower: https://research.fhstp.ac.at/en/projects/vast-virtual-airspace-and-tower; Braking system for marshalling humps https://research.fhstp.ac.at/en/projects/braking-system-for-marshalling-humps2
- Attending conferences (e.g. on smart mobility or smart infrastructure), being updated in the social media and different platforms. Dissemination and knowledge management.

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4.2.2 ERRAC panel discussion

In the framework of the collaboration between TER4RAIL project and the European Rail Research Advisory Council ERRAC, a panel discussion on rail research and innovation was jointly organized during the ERRAC Plenary that took place the 21st of March 2019 in Brussels. The meeting was attended by more than 80 participants representing the main European operators, infrastructure managers, manufacturers and academia in the railway sector.

Figure 13: General picture of ERRAC Plenary on 21st March 2019

The structure and the content were fully aligned with the online questionnaire for railway stakeholders organized under Task 1.1. The panel was conducted by Mr. Alberto Parrondo, ERRAC chairman and Thales VP, and counted with the participation of five professionals representing different actors of the railway sector: university, industry, mainline operator, infrastructure manager, urban operator.

The speakers invited were:

- Michael Pellot, Director of Innovation, at Transports Metropolitans de Barcelona.
- Henk Samson, Senior Programme Manager Business Development & Innovation, coordinator of Shift2Rail participation, Strukton Rail
- Clive Roberts, Birmingham University
- Christophe Cheron, SNCF – Innovation & Recherche
- Mark Gaddes, Network Rail

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The questions, that were prepared by TER4RAIL WP1 partners covering the four content-wise blocks of the questionnaire, were:

- **Collaboration with other stakeholders** on research and innovation is crucial. How and in which topics does your entity collaborate with **rail stakeholders** and with stakeholders **from other sectors** (could you please give examples)? *Please put special emphasis on novelties / best practices in the way to collaborate with other actors, and the relationship (existing or desired) with other sectors.*
  What are the main obstacles you find for collaboration?
- Could you please name the **technologies or innovations** that have the potential to transform your activity **in the coming decades**? *Consider positive or negative impacts.*

- Which one would you say is **the future greatest challenge / strength** of the railway sector from the R&I point of view? *May this be coming from technology, regulation, institutional framework or other.*

Figure 14: Picture of TER4RAIL Panel at ERRAC Plenary on 21st March 2019

As a brief summary of the issues discussed and the main points that arose during the debate, it can be said that while talking on **collaboration with other stakeholders**, the following sectors were mentioned:

- Intelligent Transport Systems
- Aeronautic sector
- Space sector
- Artificial Intelligence
- Agriculture (highly experienced in automatization; gardening)
- Highways (e.g. on surveillance from the air)
- Construction industry
- Safety stakeholders

There was a common agreement on the relevance of collaboration and it was acknowledged the **role played by Shift2Rail** as a great tool for the railway sector collaboration. It was also mentioned that the closer to the market one is, the more difficult is collaboration.

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Regarding the type of stakeholders, the following ones were mentioned:

- Start-ups
- Alliances for SMEs
- Alliances for Universities
- Work with other Directorates-General (DGs) different to DG MOVE and DG RTD
- Sector associations working groups
- Collaboration outside Europe
- Combination of collaboration on low-level TRL as well as deployment

When discussing obstacles for collaboration, these were the aspects arising:

- Time
- Daily obligations
- Fast deployment
- Security constraints
- Low speed for the introduction of innovations
- On-site testing is a bottleneck
- Possible competition or conflict of interest. Need to find trust
- Internal organisational obstacles
- Language barrier
- Rail seems to be less interesting than other sectors to attract researchers and academia
- Main customers are public companies: competition can complicate collaboration

Regarding **technologies or innovations** that have the potential to transform their activity in the coming decades, these ones were mentioned (random order):

- Automation (sensors, internet of things)
- Artificial Intelligence
- Digitalisation
- Robotization
- Digital twin
- MaaS
- Big data
- New business models
- Safety
-

When answering to the **greatest challenge / strength** of railways, these items were mentioned:

- Skills and people
- Railway as the backbone of the mobility of the future
- Digitalization, integration (mobility) and open innovation

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- Shift2Rail 2
- Artificial intelligence
- Robotisation
- Safety of workers

4.2.3 Interviews

A set of interviews / specific questionnaires addressed to European rail sector associations have been planned in order to complement the information obtained through the questionnaire and help to identify key points to be addressed in further stages of WP1.

The sector associations approached through this process are the ones participating at TER4RAIL: UNIFE, UIC, UITP, EURNEX, NEWOPERA.

A common structure of answers to be obtained has been prepared, in a questionnaire format. One person from each organisation, among the participants of TER4RAIL, is responsible to collect the information inside the sector association, making use of the most appropriate means (e.g. interviews with different managers / colleagues, checking strategic policy documents, etc.). This exercise will be a bridge with Task 1.2., as it will also include specific questions on their current cooperation with non-rail technology platforms and public-private partnerships. For this reason, it has been started during task 1.1. (template for questionnaire, initiate gathering responses) and will continue during task 1.2. (collection of responses by June 2019). The final version of the structure of the interviews has been included inside the appendix section.

The activities performed at TER4RAIL are developed in close cooperation with Shift2Rail and ERRAC with the aim of supporting each other and aligning efforts for a more successful rail research. In the case of ERRAC, contact with WG2 is maintained, as this group deals with collaboration with other technology platforms and the identification of projects, and feedback on the evolution of the project is provided at each ERRAC Steering Committee meeting by the Project Coordinator. Regarding Shift2Rail, communication and feedback with the Secretariat is taking place and involvement of specific members of Shift2Rail through questionnaires and interviews may be considered through the whole WP1 according to the needs and developments of the activities.

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4.3 Projects

In order to contribute to the delivery of a comprehensive map of rail research and innovation, an exercise for revision of R&I railway projects has been undertaken. Gathering knowledge on what has been done facilitates developing research beyond the state-of-the-art, contributes to avoiding duplications, supports more successful rail research and innovation and provides information on the capacities of the railway sector as a whole.

The reasoning behind the scanning of projects is to constitute an information base for further stages of TER4RAIL WP1, as well as providing easily accessible information and knowledge on projects already undertaken. It is not an end, but a mean to stimulate the transfer of knowledge and networking, through the identification of actors and expertise. Thus, it should be a living document accessible to the whole railway sector. Actions are undertaken to support this objective.

4.3.1 Methodology

As a start, several decisions were taken to focus on the analysis. It was decided to look at projects that comply with the following criteria:

- European public funding, with information publicly available
- Undertaken in the last five years (→ it was decided to focus on Horizon 2020 projects)
- Rail-related projects, understanding this as projects fully oriented to any area of the railway sector or projects with a specific part/pilot dedicated to railways

The identification of railway R&I projects has been performed using a combination of means and sources:

- Information contained at the Shift2Rail website
- Analysis of the work programmes of every call of the Societal Challenge Smart, green and integrated transport, and the corresponding projects awarded per topic
- Search at the Funding and Tenders Portal using key words
- All this has been complemented with the collaboration of TER4RAIL partners, exchange with rail stakeholders, google search, among others.

Once a preliminary list of projects was identified, information from each project was collected from the Funding and Tenders Portal of the European Commission (prior CORDIS) and gathered in an excel file that constitutes the main result of this task. The creation of the excel is dated on 29th of March 2019.

The database was constructed with the following information:

- YEAR : refers to the year in which the call for proposals was issued.
- ACRONYM : acronym of the project
- TITLE : full title of the project
- OBJECTIVE : objective of the project
- FUNDING PROGRAMME : refers to the part of Horizon 2020 under which the project was financed.
- TOPIC : topic under which the project was selected after a competitive call for

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proposals.

- ID : identification number given by the European Commission
- START DATE : date of project start
- END DATE : date of project end
- FUNDING SCHEME : type of action
- TOTAL BUDGET : total project budget
- ecMaxContribution : financial contribution by the European Commission
- % EC Contribution : % of contribution from the European Commission in relation to the total budget of the project
- COORDINATOR : name of coordinating entity
- COORD.COUNTRY : country of coordinating entity
- PARTNERS : name of partner entity/ies
- PART.COUNTRY : country of partner entity/ies

This database is accessible and available for any interested party in an excel format at the TER4RAIL website (www.ter4rail.eu), facilitating stakeholders the possibility to extract and consult the information of their interest.

It is important to take into account that this is a living document that requires continuous update. There may be projects not yet identified that could be included in the list, as well as newly awarded ones in further calls for proposals. For this reason it could not be considered as an exhaustive list of all rail-related projects under Horizon 2020, but as a very complete one of the projects that TER4RAIL has identified in collaboration with railway stakeholders.

This information will be used to raise the interest form stakeholders, stimulate discussions and attract attention form rail and non-rail entities towards the rail sector. It helps to ultimately stimulate rail research and innovation, providing information on projects already undertaken; innovations delivered by those projects: partners that have participated in them; as well as information on different funding programmes, encouraging the railway sector to make use of all the possibilities still open before the end of Horizon 2020. The dedicated actions undertaken to contribute to this objective are the following ones:

- Creation of a dedicated section on **TER4RAIL's website** (https://ter4rail.eu/2019/04/11/rail-project-scan/), that includes:
  - Basic information on the railway projects scan exercise
  - Complete rail-related projects database for download (excel document)
  - Sort PowerPoints with rail-related projects funded per type of funding: information is presented in a more visual way, listing the acronym and title of the projects in a table, and providing the links to the Cordis factsheet and project website, when available.

  The database and short PPTs will be updated every 6 months (Nov. 2019, May and Nov. 2020).
- Dissemination of the information through **social media**: information on the results of the rail-related projects scan is distributed to the social media (as a whole and per type of funding programme), trying to engage both rail and non-rail actors. Specific information on different funding programmes will also be provided, such as the opening of calls, characteristics of each type of funding instrument, examples

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of previous rail-related projects financed under a specific instrument. Opportunities for the railway sector to participate as experts or evaluators, possibilities for dissemination will also be highlighted, as well as identifying publications related to rail-related projects, such as the ones done by the Research*eu magazine, and disseminating them.

These actions will continue through the whole duration of TER4RAIL project, despite Task 1.1. is finished in M6, and fill follow the guidelines of D.4.1. in relation to the publication and interactions with Shift2Rail's newsletter and social media.

- A **specific letter** presenting the rail-related projects scan exercise will be elaborated and sent to key stakeholders such as ERRAC working groups, Shift2Rail, key associations, etc. This action will take place once D.1.1 is finished.

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4.3.2 Results in brief

As a result of the analysis of the projects financed under Horizon 2020, 179 rail-related projects have been identified. Hereafter, a summary of the distribution of the identified projects per H2020 section is provided:

- Shift2Rail Joint Undertaking - *Call for Members: 27 projects; Open Calls: 36 projects*
- Societal Challenges
  - Smart, green and integrated transport - *27 projects*
  - Secure societies - protecting freedom and security of Europe and its citizens – *4 projects*
  - Secure, clean and efficient energy - *1 project*
- Excellent Science – Marie Skłodowska-Curie Actions - *9 projects*
- Applications in Satellite Navigation - *5 projects*
- Industrial Leadership - *5 projects*
- SME Instrument - *55 projects: 38 Phase I; 17 Phase II*
- Fast Track to Innovation - *5 projects*
- Factories of the Future PPP – *2 projects*
- 5G Infrastructure Public Private Partnership – *1 project*
- ECSEL Joint Undertaking – *2 projects*

At the moment of writing this document (April 2019), the complete data from 2018 projects is not available[17]. Thus, the analysis coming hereafter is referring only to the projects identified in the range from 2014 to 2017. Tables and figures have been elaborated based on the information gathered through the scan. Full data is available at www.ter4rail.eu in excel format and as a summary in Annex 6.3.

National Projects

An important part of rail research and innovation performed across Europe takes place at the different European Member States. Gathering knowledge on national and regional rail-related projects would strongly contribute to the main objective of task 1.1. However, aspects like the disparity in the type/structure of public funding programmes, political changes, language barriers, scarce information available via web search, make this a very complex exercise.

There are currently two global databases from where **information on rail research and innovation projects** performed at the national level can be extracted. These are:

Transport Research and Innovation Monitoring and Information System (TRIMIS). This database features a vast number of projects at European (FP4, FP5, FP6, FP7 and Horizon 2020), national and international levels. It allows the search of projects per transport modes, being able to filter the results per country, STRIA Roadmap, Transport sector, transport policy, geo-spatial type, technology and funding origin.

When selecting "Rail Transport" combined with "Project" content type at TRIMIS database (10/05/2019), it shows 552 results, whose distribution per country is: European (283); International (51); Austria (20);;

[17] Information regarding project data has been obtained from CORDIS database.

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Bulgaria (6); Croatia (8); Czech Republic (28); Denmark (4); Estonia (7); Finland (9); France (15); Germany (12); Hungary (1); Ireland (1); Italy (3); Latvia (1); Lithuania (2); Luxembourg (1); Netherlands (4); Norway (14) Poland (2); Portugal (2) Romania (2); Slovakia (12); Slovenia (7); Spain (10); Sweden (14); Switzerland (23); United Kingdom (10).

SPARK, the Rail Knowledge Hub, is a free, interactive web tool for the rail industry sector to share knowledge, reduce duplication and speed up innovation. It helps users to understand what is known and who knows it, and created opportunities for networking and cooperation, creating a community of professionals.

It includes 1,576 references on rail research projects, with the following possibilities for geographical classification: Any Country; United Kingdom; Europe; European Union; Australia; Spain; Asia Pacific; Other; Europe/Asia Pacific/Middle-East; Finland; Germany; Global; Denmark; Europe/Asia Pacific/America.

Additionally, more **general information** on how is transport /rail research and innovation structured at the different member states and countries, as well as the funding programmes set up at national level, can be found in the following sources:

The compendium of Transport Research Funding, from the Transport Research & Innovation Portal (TRIP), presents an overview of transport research and funding in the European Research Area and beyond, in a total 36 countries.
It includes a description on how is transport research and innovation structured in the different countries, as well as the national government departments and agencies, and existing funding sources and support initiatives.
It was published in 2014 and is available at the Publications Office of the European Union. Link.

This information is currently updated and available at the Transport Research and Innovation Monitoring and Information System (TRIMIS) already mentioned before. It displays online country profiles from the 28 EU Member States and 11 additional countries, with information on policy background, institutional framework, funding sources and support initiatives

The FOSTER-RAIL project was set up to support the activities of ERRAC – The European Rail Research and Advisory Council and its working groups, addressing the challenge to strengthen and support research and innovation cooperation strategies in the European rail sector.
In provided two very interesting deliverables that may be useful to understand rail research and innovation at the national level:

- D1.2. Developing links and coordination strategies between ERRAC, EU and national technology platforms. State-of-the-art. *37 countries approached. Factsheets available from: Austria, France, Czech Republic, Germany, Greece, Hungary, Iceland, Ireland, Latvia, Lithuania, Italy, Macedonia, the Netherlands, Poland, Serbia, Slovakia, Spain, Estonia, Sweden, Switzerland, United Kingdom.*

- D1.4. Developing links and coordination strategies between ERRAC, EU and national technology platforms. Recommendations for the future, 2016

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In order to complement the information available, TER4RAIL has contacted the **States Representatives Group (SRG)**, the body of the Shift2Rail Joint Undertaking that comprises representatives of the EU Member States and of the countries associated with Horizon 2020, to seek collaboration from its members to gather data on National Rail R&I Projects.

They were asked for a compilation of national projects that fulfil these conditions:

- Research and innovation projects
- Financed under a public competitive call
- Rail-related, understanding this as projects fully oriented to any area of the railway subsystems or projects with a specific part/pilot dedicated to railways
- Information in English
- Data to be gathered, when possible: Year or the call; Acronym; Title; Objective; Funding Programme; Start Date; End Date; Total Budget; Coordinator; Partners (see as an example the excel file attached for the information already gathered for the H2020 projects)
- Any format, preferably excel.

The information provided will be uploaded at TER4RAIL website and made available to the key rail R&I stakeholders, being part of the Railway Projects Scan. At the moment of writing this deliverable, information has been collected from Austria (87 projects), Belgium (1 project) and Spain (98 projects), and is expected to be complemented with data from the United Kingdom.

Railway stakeholders would also be encourage to continue updating and enlarging the national railway projects scan.

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4.3.3 Analysis of rail H2020 projects (2014-2017)

This section looks in more detail to the rail projects[18] undertaken in Horizon 2020 between 2014 and 2017, both inclusive. During these four years, a total of 156 rail-related projects have been identified, being the distribution per year[19] as follows:

Year	# Projects
2014	38
2015	43
2016	35
2017	40
Total	**156**

Table 5: Distribution of the number H2020 rail-related projects per year (2014-2017)

Looking at different parts of Horizon 2020, as represented by the graphics below, Shift2Rail Joint Undertaking gathers the majority of railway projects, raking on the top in terms of budget and also having one of the highest figures in relations to the number of projects (48 projects). In this sense, it is important to mention that the four Shift2Rail lighthouse projects (Roll2Rail, IT2Rail, In2Rail and Smart-Rail), financed under the 2014 call for proposals of Smart, green and integrated transport, have been included under the Shift2Rail umbrella for the graphics below.

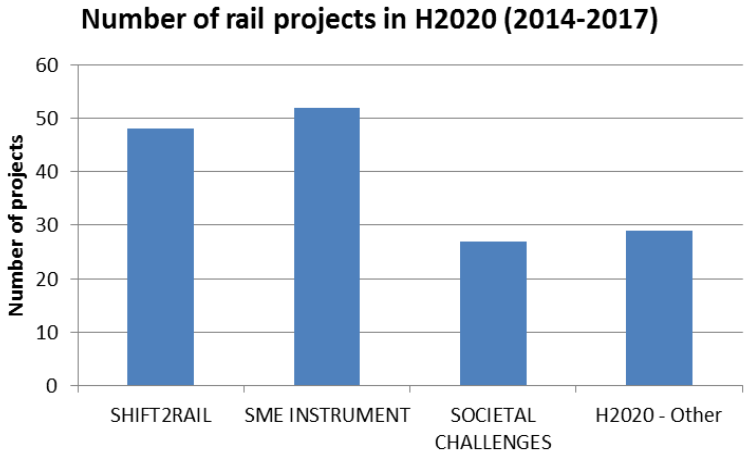

Figure 15: Number of rail-related projects in H2020 per type of funding programme (2014-2017)

[18] Rail related projects are understood as projects fully oriented to any area of the railway sector or projects with a specific part/pilot dedicated to railways.

[19] "Year" refers to the year of the call for proposals under which the project was selected for financing.

Continuing with the figures related to the number of projects, the SME Instrument is raking slightly higher as Shift2Rail, with 52 projects identified in the period 2014-2017. This facility is financing smaller projects, especially those ones of Phase 1, so the relevance of the rail-related projects selected under this instrument is smaller in terms of budget.

Societal Challenges of Horizon 2020 are an important section where rail-related research and innovation projects are concentrated. It gathers 27 projects (22 of which corresponds to Smart, green and integrated transport), with an important allocation of funding.

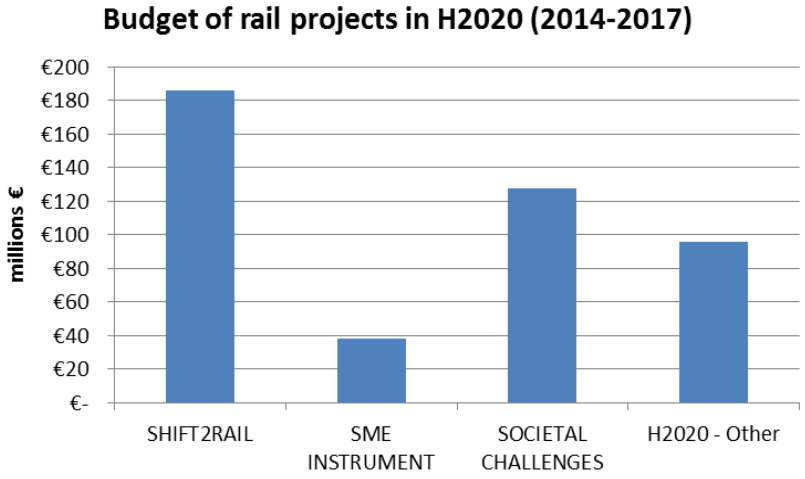

Figure 16: Budget of rail-related projects in H2020 per type of funding programme (2014-2017)[20]

Finally, "H2020-Other" gathers rail-related projects financed under other sections of Horizon 2020, such as Fast Track to Innovation, Applications in satellite navigation, Excellent Science, Industrial Leadership, the Factories of the Future Public-Private Partnership , the 5G Infrastructure Public-Private Partnership and the Electronic Components and Systems for European Leadership Joint Undertaking. They represent areas in which rail-related projects play a less relevant role, with a lower number of projects / budget in comparison with other sections such as Shift2Rail or Societal Challenges. This is at the same time a very interesting opportunity for further room to finance rail-related activities.

[20] ENABLE-S3 project has been excluded from data of Figure 16 due to its very high budget and difficulty to identify the part related to railways.

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Looking at the nationalities of the participants through the 156 rail-related projects identified under Horizon 2020 between 2014 and 2017, there are 33 different countries present. The number of projects in which every country is present out of the 156 identified, and the number of them in which an entity based in them is coordinating, is showed at the following table.

Country	Coordinator	Total Projects
ES	34	88
DE	18	79
IT	22	75
UK	23	74
FR	8	61
BE	18	45
SE	6	35
AT	9	33
NL	2	24
CZ	0	21
PT	2	21
EL	1	15
CH	0	13
IE	3	11
NO	0	11
PL	2	11
SI	1	11
FI	1	10
SK	0	8
TR	0	8
DK	3	7
IL	0	4
HR	0	3
HU	0	3
LU	0	3
LV	3	3
RO	0	3
BG	0	2
CY	0	1
EE	0	1
RS	0	1
UA	0	1
US	0	1

Table 6: Country presence at H2020 rail-related projects (2014-2017)

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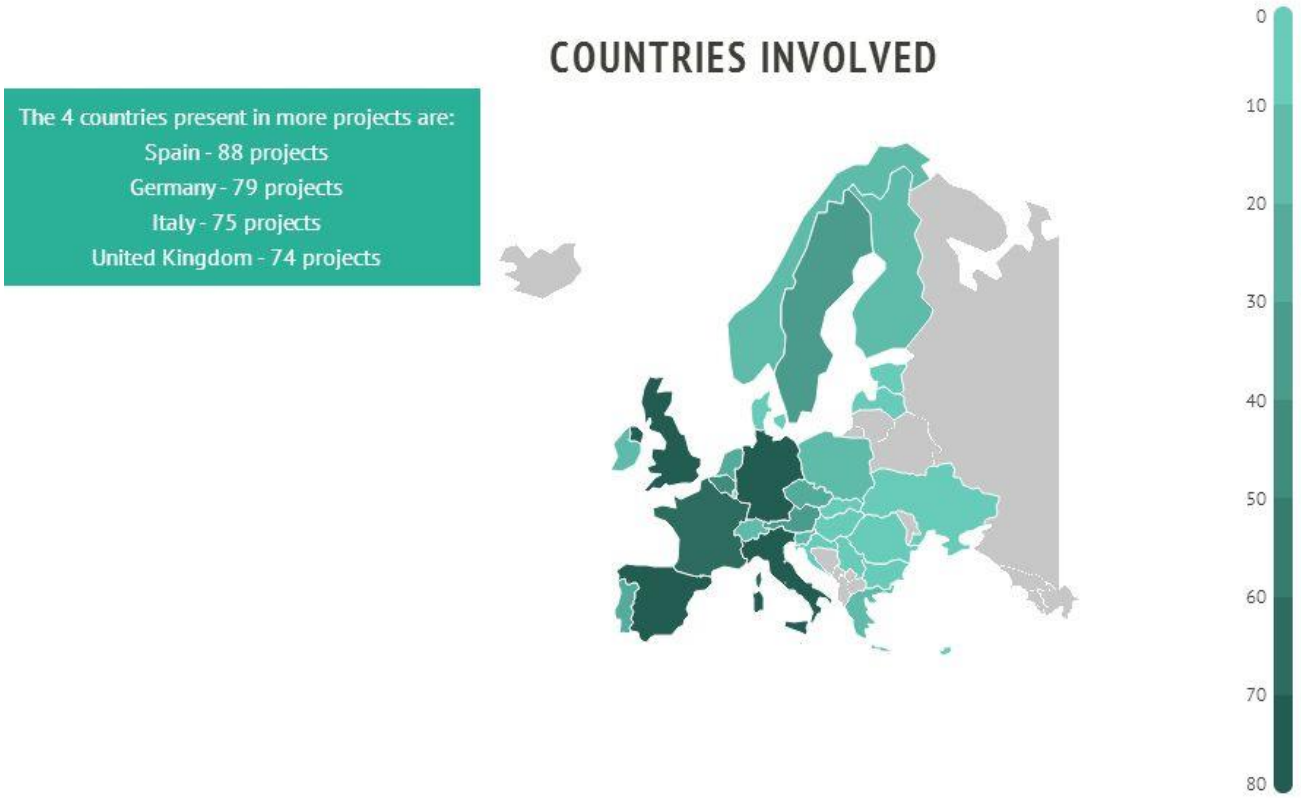

Figure 17: Most frequent country presence at H2020 rail-related projects (2014-2017)

Regarding the aspects mentioned in the descriptions contained in the field title or objective of the identified projects, the following figure shows a graphical representation of some of them.

Figure 18: Example of concepts considered by H2020 rail-related projects (2014-2017)

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SHIFT2RAIL

Information regarding Shift2Rail awarded projects is available at Shift2Rail's website[21] in a very transparent and easily accessible way. It allows to perform searches of S2R projects per Innovation Programme, year, type of call (for members, for non-members), and status (ongoing, closed), facilitating basic data form each one of the projects. Additionally, other sections of the website provide data on budget, participants, countries involved, among others. For this reason, just a brief description has been included here.

Since the creation of the Shift2Rail Joint Undertaking, three calls for proposals have taken place: a combined call 2015-2016; 2017 and 2018. Prior to them, a selection of four Shift2Rail initiative lighthouse projects took place as part of the first call of Horizon2020 under the Smart, green and integrated transport Societal challenge call of 2014. This corresponds to the projects Roll2Rail, IT2Rail, In2Rail and Smart-Rail.

Taken all this into account, there have been 63 projects directly awarded under Shift2Rail Joint Undertaking. Their distribution per year and type of call is presented underneath:

Year	CFM	OC	# Projects
2015	9	10	19
2016	4	4	8
2017	7	10	17
2018	7	12	19
Total	27	36	63

Table 7: Distribution of the number of S2R projects per year[22]

Additionally to R&I projects, there are also several tenders issued by Shift2Rail that can be consulted at its website.

Horizon 2020 - societal challenges

One of the priorities under Horizon2020 has been a challenge-based approach, bringing together resources and knowledge across different fields, technologies and disciplines, including social sciences and the humanities. There are seven Societal Challenges[23] under Horizon 2020:

- Health, demographic change and wellbeing;
- Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy;
- Secure, clean and efficient energy;
- Smart, green and integrated transport;
- Climate action, environment, resource efficiency and raw materials;
- Europe in a changing world - inclusive, innovative and reflective societies;
- Secure societies - protecting freedom and security of Europe and its citizens.

[21] www.shift2rail.org
[22] Own elaboration based on data presented in Annex 6.3. Data source: www.shift2rail.org
[23] https://ec.europa.eu/programmes/horizon2020/en/h2020-section/societal-challenges

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Each of them counts with a specific allocation of resources, elaboration of Work Programmes and publication of open competitive calls for proposals. The railway sector has traditionally had more active participation at the Smart, green and integrated transport Societal Challenge.

Smart, green and integrated transport

This challenge[24] aims to boost the competitiveness of the European transport industries and achieve a European transport system that is resource-efficient, climate-and-environmentally-friendly, safe and seamless for the benefit of all citizens, the economy and society.

It has been structured with three multiannual work programmes (2014-2015; 2016-2017; 2018-2020) that define the objectives and topics to be covered by each annual call for proposals.
A total of 26 rail-related projects have been identified. Four of them are the above mentioned Shift2Rail initiative lighthouse projects that were selected under the 2014 call for proposals, despite the fact that their budget is considered to belong to the Shift2Rail Joint Undertaking.

YEAR	# PROJECTS
2014	18
2015	2
2016	5
2017	1
TOTAL	**26**

Table 8: Number of rail-related projects financed by smart, green and integrated transport per year

The 2014 call took place before the official set-up of the Shift2Rail Joint Undertaking. From the 2015 call and the consecutive ones, there were specific rail-related calls published by Shift2Rail and this is one of the reasons explaining the low number of rail-related projects awarded. In addition, the tendency under Smart, green and integrated transport is to look for transversal projects, mobility/technology/problem-oriented not focusing so much in specific modes of transport.

There are entities from 29 different countries participating in the rail-related projects identified under the Smart, green and integrated transport Societal Challenge. The number of projects in which each country is having presence is represented at the graphic below. The three countries that are performing better in this ranking are Germany, having at least one participant in 85% of the projects (22 out of 26); Belgium, with presence in 73% of the projects (19 out of 26); and France with participation in 69% of the projects (18 out of 26).

[24] https://ec.europa.eu/programmes/horizon2020/en/h2020-section/smart-green-and-integrated-transport

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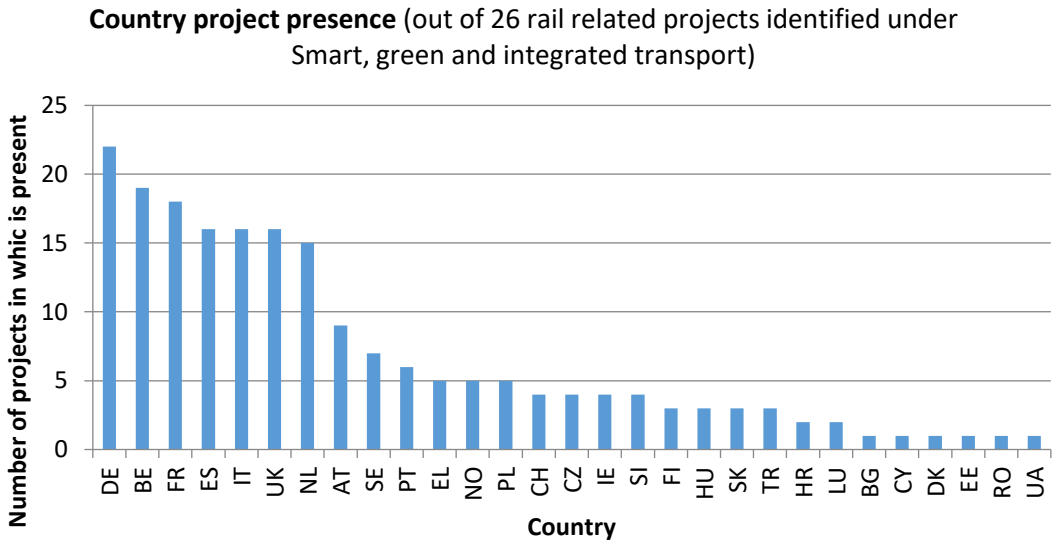

Figure 19: Country presence at the rail-related projects financed by smart, green and integrated transport

Looking at the nationality of the coordinators, the list is restricted to only 9 countries, being Belgium, leader of 31% of the projects, Spain (15%) and the United Kingdom (15%) the most frequent ones.

COORDINAT. COUNTRY	# PROJECTS
BE	8
ES	4
UK	4
DE	2
FR	2
IE	2
NL	2
EL	1
IT	1

Table 9: Coordinator country - rail-related projects financed by smart, green and integrated transport

Looking at the size of the consortium, the number of participants per project ranges from 5 partners, the smallest one, to 54 the biggest one, counting the average consortium with 16 partners. In relation to this, it is important to say that the four Shift2Rail initiative lighthouse projects involve a higher number of partners than average, ranging from 19 the smallest consortium to 54 the biggest one, being the average 34.

In total, summing up the number of partners involved in each one of the 23 rail-related projects identified, there are 406 participations, which correspond to 297 different entities.

Regarding the funding scheme of the projects, most of them are Research and Innovation Actions. There are no rail-related Innovation Actions identified under this programme.

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FUNDING SCHEME	# PROJECTS
CSA	5
RIA	21
IA	0
TOTAL	**26**

Table 10: Number of rail-related projects financed by smart, green and integrated transport per type of funding scheme

In terms of budget size, the total amount of resources allocated to the 26 projects identified is €128,634,187, being the average project size €4.947.468. This average is reduced to €3.482.337,65 per project if the four Shift2Rail initiative lighthouse projects are not taken into account, as they have a bigger size than the usual Smart, green and integrated transport call projects. Just looking at the four Shift2Rail lighthouse projects, the average size is €13,005,689.

Secure societies – Protecting freedom and security of Europe and its citizens

This societal challenge[25] is about undertaking the research and innovation activities needed to protect Europe's citizens, society and economy as well as infrastructures and services, prosperity, political stability and wellbeing.

A total of 4 rail-related projects have been identified under the calls for proposals launched for the secure societies societal challenge. Their distribution per year is shown below.

YEAR	# PROJECTS
2014	2
2015	1
2016	0
2017	1
TOTAL	**4**

Table 11: Number of rail-related projects financed by secure societies per year

These projects have an average budget size of €5,718,888, receiving two of them 100% contribution from the European Commission (Research and Innovation Actions), and the other two around 76% (Innovation Actions). Looking at the type of entities involved, these projects have an average size of 14 partners. There are 15 different nationalities present: AT; BE; CH; DE; EL; ES; FI; FR; IL; IT; NO; PT; RO; SI; UK. The most frequent ones are shown at table 12.

[25] https://ec.europa.eu/programmes/horizon2020/en/h2020-section/secure-societies-%E2%80%93-protecting-freedom-and-security-europe-and-its-citizens

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COUNTRY	# PROJECTS
ES	4
BE	3
IT	3
UK	3
EL	3

Table 12: Top 5 countries present at the rail-related projects financed by secure societies

Secure, clean and efficient energy

The energy societal challenge[26] is designed to support the transition to a reliable, sustainable and competitive energy system.

One rail-related project has been identified under the ones financed by this societal challenge. It is a Research and Innovation Action granted at the 2017 call with a consortium formed by 9 partners.

SME Instrument

The SME Instrument[27] is part of the European Innovation Council pilot. It supports groundbreaking innovative ideas for products, services or processes that are ready to conquer global markets. Available to SMEs only, the new scheme offers phased, progressive and complementary support to the development of out-of-the-box ideas. There are no predefined topics for the SME instrument call; only the most excellent and impactful ideas will receive support. In the first three years of implementation, around 4,000 SMEs will be selected to receive funding under the SME instrument call. It is structured into three phases:

- Phase 1: Feasibility assessment
- Phase 2: Innovation project
- Business acceleration and coaching offered in parallel throughout phases 1 and 2

It is a very competitive instrument financing only highly innovative SMEs. It focusses on the acceleration of market uptake, rather than research and innovation. Success rates are below 10%.

SME Instrument - PHASE 1

The outcome of the SME Instrument Phase 1 project is a feasibility study (technical and commercial), including a business plan. The amount of funding received by the selected projects is €50,000 as lump sum. Their duration is around 6 months.

In the period 2014-2017, there have been 35 rail related projects identified. Their distribution per years is the following:

[26] https://ec.europa.eu/programmes/horizon2020/en/h2020-section/secure-clean-and-efficient-energy
[27] https://ec.europa.eu/programmes/horizon2020/en/h2020-section/sme-instrument

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YEAR	# PROJECTS
2014	9
2015	10
2016	7
2017	9
TOTAL	**35**

Table 13: Number of rail-related projects financed by SME Instrument – Phase 1 per year

Looking at the country of origin of the awarded SMEs with a rail-related project, there are 11 countries represent, being Spain, Italy and the United Kingdom the most frequent ones.

COUNTRY	# PROJECTS
ES	11
IT	6
UK	5
AT	3
FR	2
LV	2
SE	2
BE	1
DE	1
DK	1
PL	1

Table 14: Country presence at the rail-related projects financed by SME Instrument – Phase 1

SME Instrument - PHASE 2

This phase finances innovation projects underpinned by a sound and strategic business plan. The amount of funding received by applicants ranges from €500,000 to € 2.5 million (covering up to 70% of eligible costs), with a duration typically around 1 to 2 years. Projects at the technology readiness level 6 or higher (technology demonstration) have the best chances to receive funding. The type of activities funded in this phase can be of several types: prototyping, miniaturisation, scaling-up, design, performance verification, testing, demonstration, development of pilot lines, validation for market replication, including other activities aimed at bringing innovation to investment readiness and maturity for market take-up.

In the period 2014-2017, there have been 16 rail-related projects identified. Their distribution per years is the following:

YEAR	# PROJECTS
2014	5
2015	1

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2016	3
2017	7
TOTAL	**16**

Table 15: Number of rail-related projects financed by SME Instrument – Phase 2 per year

12 of these projects are performed by only one entity, and 4 are undertaken in collaboration with other partners. In the case of collaboration, the size of the consortium is very small (three of the ones including partners count with only one collaborating entity and one of them with two partners).

The average budget size of the 15 identified rail-related projects is €2,031,171. Their project coordinators are coming from eight different countries, being the most frequent ones Spain, Italy and Germany.

COUNTRY COORDINATOR	# PROJECTS
ES	6
IT	3
DE	2
AT	1
DK	1
LV	1
PL	1
UK	1

Table 16: Coordinator country - rail-related projects financed by SME Instrument – Phase 2

Horizon 2020 – other areas

This section gathers rail-related projects financed under other areas of Horizon 2020, such as Fast Track to Innovation, Applications in satellite navigation, Excellent Science, Industrial Leadership, the 5G Infrastructure Public-Private Partnership and the Electronic Components and Systems for European Leadership Joint Undertaking.

Fast track to innovation

Fast Track to Innovation (FTI)[28] is a fully-bottom-up innovation support programme promoting close-to-the-market innovation activities open to industry-driven consortia that can be composed of all types of participants. It can help partners to co-create and test breakthrough products, services or business processes that have the potential to revolutionise existing or create entirely new markets, under the helm of the new European Innovation Council (EIC) pilot.

[28] https://ec.europa.eu/programmes/horizon2020/en/h2020-section/fast-track-innovation-pilot

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An analysis of the calls of 2015, 2016 and 2018 has been performed, having as a result 5 rail-related projects identified under the Fast Track to Innovation instrument.

YEAR	# PROJECTS
2015	4
2016	1
2018	0
TOTAL	5

Table 17: Number of rail-related projects financed by Fast Track to Innovation per year

The FTI aims to give the last push needed to industry led projects to reach the market, so the funding scheme of all the projects financed is Innovation Action. The average budget size of the rail-related projects identified is €2,380,636, having an EC contribution ranging from the 70% to 83%, for a typical duration of 2 years.

Regarding the number of partners involved, all the consortia are formed by 5 entities, except one that counts with only 4 partners in the consortium. There are nine different nationalities present among the project partners, being Spain (present in 80% of the projects), United Kingdom (60%), Belgium and Germany (40% each) the most common ones.

COUNTRY	# PROJECTS
ES	4
UK	3
BE	2
DE	2
CZ	1
IT	1
PT	1
SI	1
SK	1

Table 18: Country presence at the rail-related projects financed by Fast Track to Innovation

H2020 - Applications in satellite navigation

The Applications in Satellite Navigation[29] programme provides opportunities for the development of new applications for use with EGNOS and Galileo in different market segments. TER4RAIL has identified five projects directly related to the railway sector in the three calls awarded up to date.

[29] https://www.gsa.europa.eu/r-d/h2020/introduction

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YEAR	# PROJECTS
2014	1
2015	2
2017	2
TOTAL	**5**

Table 19: Number of rail-related projects financed by Applications in satellite navigation per year

The funding scheme of all of them is Innovation Action, receiving on average 81% of contribution from the European Commission in terms of budget. As a whole, they all stand for €18,883,972, being the average budget size of the projects €3,776,794.

On average, the rail-related projects financed under Applications in Satellite Navigation have a consortium composed of 12 entities. There are in total 59 participations among the five projects, which correspond to 40 different entities.

The participants gather a total of 10 different nationalities: AT, BE, CZ, DE, ES, FR, IT, SE, UK, US. In relation to the country of origin of the coordinators, three of the projects are led by an entity from Italy, one by a Belgian settled organisation and one by a Spanish organisation.

H2020 – Excellent Science: Marie Skłodowska-Curie actions

The Marie Skłodowska-Curie actions (MSCA)[30] provide grants for all stages of researchers' careers - be they doctoral candidates or highly experienced researchers - and encourage transnational, intersectoral and interdisciplinary mobility. The MSCA are open to all domains of research and innovation, from fundamental research to market take-up and innovation services. Research and innovation fields are chosen freely by the applicants (individuals and/or organisations) in a fully 'bottom-up' manner.

There are four types of MSCA actions:

- **Research networks (ITN)**: support for Innovative Training Networks
- **Individual fellowships (IF)**: support for experienced researchers undertaking mobility between countries, optionally to the non-academic sector
- International and inter-sectoral cooperation through the **Research and Innovation Staff Exchanges (RISE)**
- Co-funding of regional, national and international programmes that finance fellowships involving mobility to or from another country **(COFUND)**

TER4RAIL has identified a total of 9 rail-related projects among the ones financed by MSCA. Five of them are an Individual Fellowship (IF) projects; one has the figure of Research and Innovation Staff Exchange composed of 12 partners from 10 different nationalities (UK, PT, FR, SE, FI, CZ, IT, ES, NO, NL); and there are three Research Networks (ITN) formed by 4 partners one of them and

[30] https://ec.europa.eu/programmes/horizon2020/node/8

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9 partners the other two, and having nine different nationalities represented: DE; DK; EL; ES; FR; IE; IT; SE; UK.

YEAR	# PROJECTS
2014	1
2015	2
2016	6
TOTAL	**9**

Table 20: Number of rail-related projects financed by MCSA per year

MSCA TYPE	# PROJECTS
ITN	3
IF	5
RISE	1
COFUND	0

Table 21: Number of rail-related projects financed by MCSA per type of action

Looking at the coordination of these projects, 78% of them, 7 out of 9, are leaded by entities from the United Kingdom.

H2020 – Industrial leadership: Leadership in enabling and industrial technologies (LEIT)

TER4RAIL has identified five rail-related projects financed under the Information and Communication Technologies of the Leadership in Enabling and Industrial Technologies (ICT-LEIT)[31] area of Horizon 2020.

YEAR	# PROJECTS
2014	2
2015	1
2016	2
TOTAL	**5**

Table 22: Number of rail-related projects financed by Industrial leadership - LEIT per year

Three of them are Research and Innovation Actions with an average budget size of €5,085,105, covered 100% by the European Commission, and consortium ranging from 7 to 11 partners. The other two are Innovation Actions: a big project of €18,703,369 and 48 partners from 10 different countries (ES, IE, UK, FI, EL, DE, FR, IT, NL, LU); and a smaller one of €4,003,625 and 8 partners from four nationalities (DE; ES; SE; UK); both leaded by Spanish entities. These last two financed on average 84% by the European Commission.

[31] https://ec.europa.eu/programmes/horizon2020/en/h2020-section/information-and-communication-technologies

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Factories of the Future Public-Private Partnership

Factories of the Future[32] is the European Union's public-private partnership for advanced manufacturing research and innovation, being the main programme for realising the next industrial revolution: materialising Factories 4.0.

There have been identified two rail-related Research and Innovation Actions financed under the Factories of the Future Public-Private Partnership Calls, one in 2016 and the other one in 2017. These projects have on average 12 partners and an average size of €4,260,794.

5G Infrastructure Public-Private Partnership

The 5G Infrastructure Public-Private Partnership (5G PPP) [33] is a joint initiative between the European Commission and European ICT industry to secure Europe's leadership in the particular areas where Europe is strong or where there is potential for creating new markets such as smart cities, e-health, intelligent transport, education or entertainment & media.

In this analysis one rail-related project financed under this facility at the 2017 call has been identified. It is a Research and Innovation Action with almost 8 million Euros budget and 19 partners from eight nationalities: DE; EL; ES; FR; IL; IT; NO; UK.

Electronic Components and Systems for European Leadership Joint Undertaken

The ECSEL Joint Undertaking[34] - the Public-Private Partnership for Electronic Components and Systems – funds Research, Development and Innovation projects for world-class expertise in these key enabling technologies, essential for Europe's competitive leadership in the era of the digital economy.

Two rail-related projects have been identified under this facility: one very big project of more than 16 million Euros financed under the 2015 call that involves 74 partners and a Research and Innovation Project from the call of 2016 with 22 partners.

[32] https://www.effra.eu/factories-future
[33] https://5g-ppp.eu/
[34] https://www.ecsel.eu/

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5 Conclusions and way forward

This deliverable provides a **comprehensive map of the state-of-the-art and major tendencies in rail research environment**, as shown through the three pillars analysed: rail policy and key strategic documents; perspective of different rail stakeholders; and rail research and innovation projects undertaken by the sector, providing rich qualitative data and gaining insights on a variety of opinions around rail research and innovation.

It contributes to the objective of achieving a more successful rail research strategy by **guiding further TER4RAIL actions** and constituting the **basis of the Rail Innovative Research Observatory (RIRO).** The information gathered will be combined with the results of the identification of non-rail actors and pool of expertise and the concepts on 2050 new urban scenarios (TER4RAIL Task 1.2.) and feed the activities of the Rail Innovative Research Observatory (TER4RAIL Task 1.3.) that will focus on interacting, sharing experience and cross-fertilisation during the second half of the project.

As conclusions, some aspects that may be taken into account in the way forward are the following ones:

- The analysis of the most relevant rail policy and strategic documents delivered a vision that maps current situation and tendencies of the rail system. It must be underlined that the document elaborated by ERRAC "2030 R&I priorities towards ERRAC 2050 Vision" was considered in a draft version, as the final one was not available at the moment of writing this deliverable.
- Collaboration has been recognized to play an important role in rail research and innovation. However, the lack of synergies with other industrial sectors was mentioned as a risk during the analysis of documents, and looking at the answers provided by the survey, it seems that collaboration with non-transport sectors is less explored. It could be advisable to focus on strengthening the interactions with other technology areas / sectors already existing and establishing new ones centered on technologies instead of modes.
- In this sense, there is a consensus within the information acquired in this deliverable that the Shift2Rail JU has played a major role in building a framework in which to work forward and overcome the fragmentation within the sector, enhancing competitiveness and collaboration and helping bring rail to the forefront of innovation of the transport sector.
- When identifying specific new innovative technologies to tackle, there are several parts of this document that may help. These are: 4.1.6. Rail Innovative Technology Scanning; 4.2.1.3. Relationship with other sectors; 4.2.1.4. Disruptive technologies and innovations; 4.2.2. ERRAC Panel discussion; 4.3.2. Results in brief (thematic of the financing programmes with rail-related projects identified).
- The railway sector is capable of meeting the criteria of many different funding programmes under H2020, as shown through the rail-related projects scan. Availability of information

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on typology of the different funding programmes, key dates and deadlines, as well as examples of previous rail-related projects, may maximize the use of the remaining H2020 funding.

- Interaction and engagement of stakeholders is crucial for the development of WP1 activities, being very relevant a close collaboration with TER4RAIL WP4 Dissemination. Activities should be integrated within ERRAC and maximase as much as possible a joint way of working. The continuity of the actions addressed to the railway sector as a whole beyond the project life, may depend on the success of this collaboration. Furthermore, an alignment with Shift2Rail objectives and adaptation to its needs is essential for the usefulness of the work undertaken.

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6 Appendices

6.1 List of Rail stakeholders' key policy and strategic documents analysed

Number	Name	Author (s)
1	Rail 2050 Vision. Rail-The backbone of Europe´s mobility	ERRAC
2	Shift2Rail Multi Annual Action Plan	Shift2Rail
3	Shift2Rail Master Plan	Shift2Rail
4	Interim Evaluation of Shift2Rail Joint Undertaking (2014-2016)	Shift2Rail. Written by: Eric Fontanel, Roderick Smith, Heather Allen, Michael Dooms
5	2030 R&I priorities towards ERRAC 2050 Vision	ERRAC
6	12 Capabilities – A Presenter's Guide	UIC-RICG
7	A Project book: The Railway Operating Community (ROC) involvement in EU projects	UIC-RICG
8	Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system	European Commission
9	Global Vision for Railway Development	UIC-IRRB
10	Railway Technical Strategy Europe	UIC
11	STRIA- Cooperative connected and automated transport Roadmap	European Commission
12	STRIA- Low emission, alternative energy for transport roadmap	European Commission
13	STRIA- Transport Infrastructure roadmap	European Commission

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14	STRIA-Vehicle design and manufacturing roadmap	European Commission
15	STRIA-Network and traffic management systems roadmap	European Commission
16	STRIA- Smart mobility and services roadmap	European Commission
17	STRIA- Transport electrification	European Commission
18	UNIFE Position Paper on Digitalisation of Railways	UNIFE
19	Establishing rail as the backbone of future mobility	UNIFE
20	Annual Activity Report 2017	Shift2Rail
21	Research for TRAN Committee - Modal shift in European transport: a way forward	EUROPEAN PARLIAMENT
22	Urban Rail Research Priorities – Urban perspective + VISION	UITP
23	Main public transport trends and developments outside Europe	UITP
24	Priorities and trends for light rail operators: Survey Results	UITP, Light rail committee
25	Metro operators priorities 2016	UITP, Metro Committee
26	Public Transport Trends 2017, Public Transport Trends 2019	UITP
27	Future of Rail 2050	ARUP
28	Presentation of Urban Air Mobility	EIP-SCC

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6.2 TER4RAIL- Questionnaire to Rail Stakeholders

TER4RAIL is an **EU funded project from the Shift2Rail Joint Undertaking** under the European Union's **Horizon 2020 research and innovation program**. Its main aim is to identify and monitor new opportunities for innovative research and facilitate the cross-fertilization of knowledge from other disciplines into rail.

The following questionnaire, has the aim of delivering a comprehensive map of the state-of-the-art and major tendencies of innovative research in rail technology and key stakeholders in the R&I of rail-related activities with the ultimate objective to contribute to the structuring of interactions that may lead to networking, cross-fertilisation, common collaboration and the kick-starting of new ideas.

All suggestions, questions or contributions, and the filled in document must be sent to TER4RAIL partner, the Spanish Railway Foundation (FFE) responsible for their analysis, to Aida Herranz (aherranz@ffe.es) and Eduardo Prieto (eprieto@ffe.es).

Please, indicate some basic information[1]

1. NAME OF ENTITY :_____

2. TYPE OF ENTITY:

☐ RAILWAY OPERATOR / INFRASTRUCTURE MANAGER
☐ SUPPLIER
☐ UNIVERSITY
☐ RESEARCH CENTRE
☐ OTHER (*please specify*) : _____

Please answer the following questions taking into account the last five years (2014-2018) of R&I activities inside your organisation.

Organisation of Research and Innovation (R&I) inside the entity

3. Does your organisation have a Research and Innovation strategy?

☐ YES / ☐ NO

4. If so, when possible please send it back together with this questionnaire.

☐ YES I ATTACH IT / ☐ NO, I DO NOT

5. When performing R&I activities, what type of funding source does your organisation use?

☐ Own funding
☐ Private capital (e.g. banks, venture capital…)
☐ National/Regional Public Funding. Please name the funding programmes: _____
☐ European Public Funding. Please name the funding programmes: _____
☐ Other: _____

Could you please name the Regional / National / European Public Funding programmes in which

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your entity has participated?_____
If additionally your entity makes use of other type of R&I funding source different to the options provided please explain it also here _____

6. When selecting different sources, could you please estimate the % that each one represents, taking into account the last 5 years?

   _____

7. Have you participated in the Shift2Rail initiative? ☐ YES / ☐ NO
   If so, please specify how (founder member, associate member, open call projects or other)

   _____

8. When you undertake R&I activities, which estimated percentage does your organisation perform in collaboration with other partners and which percentage individually? *Please take into account the last 5 years. Indicate if you are referring to the number of projects, funding volume, etc.*

   In collaboration with other partners: ___ %
   Individually: ___ %

9. How important are the following drivers in the motivation of your organisation to undertake research and innovation actions?

	High	Medium	Low	Not relevant
Identification of a gap in what the market offers	☐	☐	☐	☐
Making use of ideas or scientific/technological novelties	☐	☐	☐	☐
Making use of an idea generated inside the company	☐	☐	☐	☐
Compliance with regulation	☐	☐	☐	☐
Technical Problem	☐	☐	☐	☐
Availability of public support mechanisms	☐	☐	☐	☐
Increase range of offered goods and services	☐	☐	☐	☐
Replace outdated products or processes	☐	☐	☐	☐
Enter new markets	☐	☐	☐	☐
Increase market share	☐	☐	☐	☐
Improve quality, flexibility and/or capacity of goods and services	☐	☐	☐	☐
Reduce labour costs per unit output	☐	☐	☐	☐
Energy efficiency and sustainability				
Other: _____	☐	☐	☐	☐

10. If other, please specify

    _____

11. How important are the following factors in hampering your research and innovation actions or influencing a decision not to innovate?

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		Degree of importance			
		High	Medium	Low	Factor not experienced
Cost factors	Lack of funds within your organisation or group	☐	☐	☐	☐
	Lack of funds from outside	☐	☐	☐	☐
	Innovation costs too high	☐	☐	☐	☐
Knowledge factors	Lack of qualified personnel	☐	☐	☐	☐
	Lack of information on technology	☐	☐	☐	☐
	Lack of information on markets	☐	☐	☐	☐
	Difficulty in finding cooperation partners for innovation	☐	☐	☐	☐
Market factors	Market dominated by established organisations	☐	☐	☐	☐
	Uncertain domain for innovative goods or services	☐	☐	☐	☐
	Need to meet regulations	☐	☐	☐	☐
	Excessive perceived economic risk	☐	☐	☐	☐
	Difficult market uptake	☐	☐	☐	☐
Reasons not to innovate	No need due to prior innovations	☐	☐	☐	☐
	No need because no demand for innovations	☐	☐	☐	☐
Risk aversion		☐	☐	☐	☐
Other: _____		☐	☐	☐	☐

12. If other, please specify

    _____

13. Which measures have your organisation taken in order to overcome these barriers? Could you please provide examples?

    _____
    _____

14. Has your organisation implemented the results of R&I activities to develop a new/improved service/product?

    ☐ YES / ☐ NO

    If yes, could you please indicate how these results have been implemented?

    _____

15. If you are **from a University**, and you have the following information, could you please let us know how many **Railway Doctoral Thesis** have been undertaken in your university on the last 10 years?_____ NAME OF UNIVERSITY: _____

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16. If answering the previous question, do you have figures on which thematics those thesis have been focussed on? If so, please indicate them._____

RELATIONSHIP WITH OTHER STAKEHOLDERS

17. From the following list of possible external collaboration partners, please select the ones with whom your organisation collaborates on research and innovation (*you may select more than one partner type*)

- ☐ Suppliers
- ☐ Operators
- ☐ Customers
- ☐ Universities
- ☐ Research Institutes
- ☐ Complementary firms
- ☐ Start-ups
- ☐ Consultants
- ☐ None
- ☐ Other: _____

18. What type of collaboration for R&I does your organisation establishes with other stakeholders?

- ☐ Private contract (e.g. subcontracting, joint venture, etc.)
- ☐ Acquiring a smaller firm, available licenses, patents, etc.
- ☐ Collaboration through public research instruments
- ☐ Open innovation instruments, such as hackathons, incubators, prizes, etc.
- ☐ Other (Please specify)_____

19. When selecting several ones, could you please indicate which one is the most commonly used by your organisation, and outline the advantages and disadvantages of this collaboration?

_____
_____

RELATIONSHIP WITHIN THE RAILWAY SECTOR ON R&I

20. Does your organisation use as a reference / follow any of the following in relation to R&I issues?

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- ☐ UNIFE
- ☐ UIC
- ☐ UITP
- ☐ EIM
- ☐ CER
- ☐ ERA
- ☐ ERRAC
- ☐ DG MOVE - EUROPEAN COMMISSION
- ☐ DG RTD – EUROPEAN COMMISSION
- ☐ SHIFT2RAIL
- ☐ Other: _____

RELATIONSHIP WITH OTHER SECTORS

21. Does your organisation cooperate with other sectors, different to rail, on R&I rail related issues?
    ☐ YES / ☐ NO

    If so, could you please indicate which ones?
    _____
    _____

22. How does you organisation relate with other sectors on R&I activities?
    - ☐ Contracting employees from other sectors
    - ☐ The own company's activities covers different sectors
    - ☐ Establishing alliances
    - ☐ Collaboration through public research instruments
    - ☐ Through Technology Platforms, please name them:_____
    - ☐ Through business associations, please name them:_____
    - ☐ Through events, conferences, workshops, please name them:_____
    - ☐ Other: _____

23. In your opinion, with which other sectors / stakeholders, with whom your organisation does not cooperate currently on R&I rail issues, would you like to have cooperation?

    _____
    _____

24. Could you please share with us examples of good practices related to networking / cross-fertilization that have proved to be very useful for the relationship with other stakeholders (rail or non-rail) on R&I issues?

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DISRUPTIVE TECHNOLOGIES AND INNOVATIONS

25. What are, according to you, the most promising technologies or innovations that have the potential to transform the rail sector **in the coming 5 years**? *Please indicate the Top 3.*

    1._____
    2._____
    3._____

26. What are, according to you, the most promising technologies or innovations that have the potential to transform the rail sector **in the coming decades**? *Please indicate the Top 3.*

    1._____
    2._____
    3._____

27. Which sources of information does your organisation use to detect innovations?

	High	Medium	Low	Not relevant
Own employees	☐	☐	☐	☐
Client demands	☐	☐	☐	☐
Looking at competitors	☐	☐	☐	☐
Technology Monitoring	☐	☐	☐	☐
Use of patent database	☐	☐	☐	☐
Use of scientific literature	☐	☐	☐	☐
Use of market surveys	☐	☐	☐	☐
Through associations, networks…	☐	☐	☐	☐
Newsletters, magazines	☐	☐	☐	☐
Social networks	☐	☐	☐	☐
Conferences, workshops, fairs…	☐	☐	☐	☐
Other: _____	☐	☐	☐	☐

28. If you have selected "other" please specify. Feel free to add also comments/examples in the previous question

29. How is your organisation dealing with **emerging innovative** technologies? How do you get prepare to the future / continuous update?

    _____
    _____

30. How is your organisation dealing with **digitalisation**? Are there specific initiatives/plans tackle digitalisation in the coming years?

    _____
    _____

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31. Would you like to share with us examples of good practices related to the adoption /being prepared the challenges set by new innovative technologies on rail R&I issues?

    _____
    _____

32. Is there anything else you would like to share with us?

    _____

33. Would you like to keep in touch regarding TER4RAIL activities? If so, feel free to leave here you name and contact details. By doing so, you are accepting our privacy terms, as expressed below*.

    __ Yes
    __ No

*The data provided will be stored and controlled by Fundación de los Ferrocarriles Españoles (FFE) in compliance with the information set out in the Act 3/2018 on the Personal Data Protection and Guarantee of Digital Rights and the provisions of the General Data Protection Regulation (Regulation (EU) 2016/679 of 27 April 2016), appliying GDPR 6.1.a) The data subject has given consent to the processing of his or her personal data for one or more specific purposes, with the objective to contact you in case of requests for further information on the topics addressed by this questionnaire or distribution of results and information from TER4RAIL project. Personal data will not be published, nor shared with third parties unless legal obligation. For further information, or making use of your rights, please consult: https://www.ffe.es/fundacion/aviso_legal_en.htm

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6.3 List of rail projects identified

SHIFT2RAIL

	IP1	IP2	IP3	IP4	IP5	CCA	IPX
Lighthouse Projects	Roll2Rail	(In2Rail) (Roll2Rail)	In2Rail	IT2Rail	Smart-Rail	(Smart-Rail) (Roll2Rail) In2Rail	
Projects 2015		X2Rail-1 VITE CYRail MISTRAL		ATTRACkTIVE Co-Active	FFL4E FR8Rail ARCC INNOWAG DYNAFREIGHT SMART	IMPACT-1 PLASA FINE 1 NEAR 2050 GoSAFE RAIL DESTINATE OPEUS	
Projects 2016	CONNECTA PINTA Safe4Rail		In2Track In2Smart S-Code	ST4RT GOF4R			
Projects 2017	PIVOT Mat4Rail Run2Rail	X2Rail-2 ASTRAIL ETALON	In2Stempo IN2DREAMS Fair Stations MOMIT	Cohesive CONNECTIVE My-TRAC	FR8HUB OptiYard	IMPACT-2 SMaRTE	
Projects 2018	CONNECTA-2 PINTA2 SAFE4RAIL-2	X2Rail-3 EMULRADIO4RAIL GATE4RAIL MOVINGRAIL	In2Track2 ASSETS4RAIL	MAASIVE SPRINT SHIFT2MAAS	FR8RAIL II M2O	PLASA-2	B4CM FLEX-RAIL MVDC-ERS TER4RAIL

Grey – initiative lighthouse projects (under H2020 Smart, green and integrated transport calls)
Blue – Call for members projects
Red – Open call projects

SHIFT2RAIL – Call for Members

YEAR	ACRONYM	TITLE
2015	**ARCC**	Automated Rail Cargo Consortium: Rail freight automation research activities to boost levels of quality, efficiency and cost effectiveness in all areas of rail freight operations
	ATTRACkTIVE	Advanced Travel Companion and Tracking Services
	Co-Active	CO-modal journey re-ACcommodation on associated Travel serVices
	FFL4E	Future Freight Loco for Europe
	FINE 1	Future Improvement for Energy and Noise
	FR8RAIL	Development of Functional Requirements for Sustainable and Attractive European Rail Freight
	IMPACT-1	Indicator Monitoring for a new railway PAradigm in seamlessly integrated Cross modal Transport chains – Phase 1
	PLASA	Smart Planning and Safety for a safer and more robust European railway sector

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2015	**X2Rail-1**	Start-up activities for Advanced Signalling and Automation Systems
2016	**CONNECTA**	CONtributing to Shift2Rail's NExt generation of high Capable and safe TCMS and brAkes. Phase 1.
	IN2SMART	Intelligent Innovative Smart Maintenance of Assets by integRated Technologies
	IN2TRACK	Research into enhanced tracks, switches and structures
	PINTA	IP1 Traction TD1 and Brakes TD5 – Phase 1
2017	**COHESIVE**	COHErent Setup and Demonstration of Integrated Travel SerVices
	CONNECTIVE	Connecting and Analysing the Digital Transport Ecosystem
	FR8HUB	Real time information applications and energy efficient solutions for rail freight
	IMPACT-2	Indicator Monitoring for a new railway PAradigm in seamlessly integrated Cross modalTransport chains – Phase 2
	IN2STEMPO	Innovative Solutions in Future Stations, Energy Metering and Power Supply
	PIVOT	Performance Improvement for Vehicles on Track
	X2RAIL-2	Enhancing railway signalling systems based on train satellite positioning, on-board safe train integrity, formal methods approach and standard interfaces, enhancing Traffic Management System functions
2018	**CONNECTA-2**	CONNECTA 2
	FR8RAIL II	Digitalization and Automation of Freight Rail
	In2Track2	Research into enhanced track and switch and crossing system 2
	MAASIVE	Passenger service platform specifications for an enhanced multi-modal transport eco-system including Mobility as a Service (MaaS)
	PINTA2	IP1 Traction TD1 and Brakes TD5 – Phase 2
	PLASA-2	Smart Planning and Virtual Certification
	X2Rail-3	Advanced Signalling, Automation and Communication System (IP2 and IP5) – Prototyping the future by means of capacity increase, autonomy and flexible communication

SHIFT2RAIL – Open Call

YEAR	ACRONYM	TITLE
2015	**CYRail**	Cybersecurity in the RAILway sector
	DESTINATE	Decision supporting tools for implementation of cost-efficient railway noise abatement measures
	DYNAFREIGHT	Innovative technical solutions for improved train DYNAmics and operation of longer FREIGHt Trains
	GoSAFE RAIL	GoSAFE RAIL – Global Safety Management Framework for RAIL Operations
	INNOWAG	INNOvative monitoring and predictive maintenance solutions on lightweight WAGon
	MISTRAL	Communication Systems for Next-generation Railways
	NEAR2050	NEAR2050 - future challenges for the rail sector
	OPEUS	Modelling and strategies for the assessment and OPtimisation of Energy USage aspects of rail innovation
	SMART	Smart Automation of Rail Transport
	VITE	Virtualisation of the testing environment
2016	**GoF4R**	Governance of the Interoperability Framework for Rail and Intermodal Mobility
	SAFE4RAIL	SAFE architecture for Robust distributed Application Integration in roLling stock
	S-CODE	Switch and Crossing Optimal Design and Evaluation
	ST4RT	Semantic Transformations for Rail Transportation

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2017	**ASTRail**	SAtellite-based Signalling and Automation SysTems on Railways along with Formal Method and Moving Block validation
2017	**ETALON**	Energy harvesTing for signAlLing and cOmmunicatioN systems
	FAIR Stations	Future Secure and Accessible Rail Stations
	IN2DREAMS	INtelligent solutions 2ward the Development of Railway Energy and Asset Management Systems in Europe
	Mat4Rail	Designing the railway of the future: Fire resistant composite materials and smart modular design
	MOMIT	Multi-scale Observation and Monitoring of railway Infrastructure Threats
	My-TRAC	My TRAvel Companion
	OPTIYARD	Optimised Real-time Yard and Network Management
	RUN2Rail	Innovative RUNning gear soluTiOns for new dependable, sustainable, intelligent and comfortable RAIL vehicles
	SMaRTE	Smart Maintenance and the Rail Traveller Experience
2018	**ASSETS4RAIL**	Measuring, monitoring and data handling for railway assets; bridges, tunnels, tracks and safety systems
	B4CM	Blockchains as a Distributed Ledger for Attribution of RCM Data in Rail
	EMULRADIO4RAIL	EMULATION OF RADIO ACCESS TECHNOLOGIES FOR RAILWAY COMMUNICATIONS
	FLEX-RAIL	Paradigm shifts for railway – Technology uptake strategies for a lean, integrated and flexible railway system
	GATE4RAIL	GNSS Automated Virtualized Test Environment for RAIL
	M2O	MAke RAil The HOpe for protecting Nature 2 future OPERATION
	MOVINGRAIL	MOving block and VIrtual coupling New Generations of RAIL signalling
	MVDC-ERS	Flexible medium voltage DC electric railway systems
	Safe4Rail-2	Smart Planning and Virtual Certification
	Shift2Maas	Shift2Rail IP4 enabling Mobility as a Service and seamless passenger experience
	SPRINT	Semantics for PerfoRmant and scalable INteroperability of multimodal Transport
	TER4RAIL	Transversal Exploratory Research Activities for Railway

Horizon 2020 SOCIETAL CHALLENGES

Smart, green and integrated transport

YEAR	ACRONYM	TITLE
2014	**BONVOYAGE**	From Bilbao to Oslo, intermodal mobility solutions and interfaces for people and goods, supported by an innovative communication network
	DESTinationRAIL	Decision Support Tool for Rail Infrastructure Managers
	ETC	The European Travellers Club: Account-Based Travelling across the European Union
	EuTravel	Optimodal European Travel Ecosystem
	FOX	Forever Open infrastructure across (X) all transport modes
	HERMES	DEVELOPMENT OF SMART AND FLEXIBLE FREIGHT WAGONS AND FACILITIES FOR IMPROVED TRANSPORT OF GRANULAR MULTIMATERIALS. (HERMES)
	IN2RAIL	Innovative Intelligent Rail
	INFRALERT	LINEAR INFRASTRUCTURE EFFICIENCY IMPROVEMENT BY AUTOMATED LEARNING AND OPTIMISED PREDICTIVE MAINTENANCE TECHNIQUES
	IT2RAIL	INFORMATION TECHNOLOGIES FOR SHIFT TO RAIL
	MASAI	MOBILITY BASED ON AGGREGATION OF SERVICES AND APPLICATIONS INTEGRATION

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	NeTIRail-INFRA	Needs Tailored Interoperable Railway
	REFINET	REthinking Future Infrastructure NETworks
	ROLL2RAIL	NEW DEPENDABLE ROLLING STOCK FOR A MORE SUSTAINABLE, INTELLIGENT AND COMFORTABLE RAIL TRANSPORT IN EUROPE
	SENSKIN	'SENsing SKIN' for Monitoring-Based Maintenance of the Transport Infrastructure
	SETRIS	Strengthening European Transport Research and Innovation Strategies
	Smart-Rail	Smart Supply Chain Oriented Rail Freight Services – Smart-Rail
	USE-IT	Users, Safety, security and Energy In Transport Infrastructure
	WRIST	Innovative Welding Processes for New Rail Infrastructures
2015	**INTERMODEL EU**	Simulation using Building Information Modeling Methodology of Multimodal, Multipurpose and Multiproduct Freight Railway Terminals Infrastructures.
	RAGTIME	Risk based approaches for Asset inteGrity multimodal Transport Infrastructure ManagEment
2016	**LessThanWagonLoad**	Development of 'Less than Wagon Load' transport solutions in the Antwerp Chemical cluster
	SAFE-10-T	Safety of Transport Infrastructure on the TEN-T Network
	SAFER-LC	SAFER Level Crossing by integrating and optimizing road-rail infrastructure management and design
	SCORE	Score board of competitiveness of European transport manufacturing industries
	SKILLFUL	Skills and competences development of future transportation professionals at all levels
2017	**FORESEE**	Future proofing strategies FOr RESilient transport networks against Extreme Events

Secure societies - protecting freedom and security of Europe and its citizens

YEAR	ACRONYM	TITLE
2014	**AUGGMED**	Automated Serious Game Scenario Generator for Mixed Reality Training
	BODEGA	BOrdDErGuArd - Proactive Enhancement of Human Performance in Border Control
2015	**CIPSEC**	Enhancing Critical Infrastructure Protection with innovative SECurity framework
2017	**CYBERWISER.EU**	Civil Cyber Range Platform for a novel approach to cybersecurity threats simulation and professional training

Secure, clean and efficient energy

YEAR	ACRONYM	TITLE
2017	**E-LOBSTER**	Electric LOsses Balancing through integrated STorage and power Electronics towards increased synergy between Railways and electricity distribution networks

SME Instrument - Phase 1

YEAR	ACRONYM	TITLE
2014	**eco-railjacket**	Total Full Ecologic Embedded Railways Jacket System
	Greenrail	Greenrail: sustainability, safety and saving in the the railroad sleeper of tomorrow
	ITECCO	Innovative Transport Equipment for Coal, Coke and Ore
	LCODA	Electronic scanning MIMO Radar for railway level crossing obstruction detection alerting
	OpticTrainDetection	Optical and Acousto-optic Sensor Technology for Railway-Applications
	OTR	Off The Rails
	SEEABLE	An Innovative ICT Solution for Providing Bespoke Safety and Health Training to Workers in the Construction and Transportation Sectors.

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	TRAINSFARE	Transport System with Artificial Intelligence for Safety and Fare Evasion
	Tunnelsafe2020	Road and rail tunnel fire protection
2015	**CALIPRI**	CALIPRI - an easily customisable all purpose optical gauge for 2D-profiles.
	D3IMPACT	Data-driven decisions for intelligent management of public transportation
	DIDSON	Paracoustics : System active sound reducing system against noise pollution due to transport
	DIGITALIA	Disruptive process for the construction of railway transition zones, reducing drastically construction and maintenance costs
	FAST-TRACKS	Fast rAdio technologieS for uninterrupTed TRAin to traCKside communications
	NET4TRAIN	Revamping trains with the most advanced broadband communication system
	SAFT	Ultrasonic Inspection Solution for railway crossing points
	smaRtAIL	Smart protective coatings on classic materials for a new generation of ecologically sustainable 'green' railway vehicles
	tCat WorkStation	New adaptable equipment for geometric auscultation of railways and overhead lines
	TRACKSCAN	A practical, portable and robust scanning system using infrastructure inspection radar (IIR) for the investigation of rail track substructure, ballast and tunnel infrastructure
2016	**DiGas Dual fuel**	A novel dual fuel system for diesel locomotive modernisation to CNG or LNG operation
	DTD SYSTEM	A disruptive innovation for the minimisation of railway maintenance costs
	GRAILS-SWE	Greater RAIL Safety using the Smart Washer Ecosystem
	POWERVE	Portable Weigher for Railway Vehicles
	ReVibe	Vibration energy harvesters to power the IoT revolution
	Skylynx	Upgrading Railways from the Air
	TADIL and DITEL	TADIL and DITEL
2017	**DIAG-PANTOGRAPH**	Train Pantograph equipped with diagnostic system for reduction of faults and maintenance cost
	IntelHeat	Intelligent control system for railway points heating with supreme saving of electricity
	LEDVAR-Z	A New Paradigm for Efficient and Modern Rail Signalling
	MOTIONPult	Advanced composites for lightweighting land transport structures using pultrusion process
	OMNISCIENT	Prediction and optimisation platform for the mobile assets management
	Railscope	Improving Railway Safety Through Innovative Sensor System
	RPS	Disruptive Radar Positioning System for trains
	SPEED-EU	Damping device to solve the pantograph-line capture problems, especially for the EU high-speed railways lines
	VERT	Vertex switch – the foundation for a more sustainable and reliable railway transport system

SME Instrument – Phase 2

YEAR	ACRONYM	TITLE
2014	**COMPOSKE**	Development of a new technology for production of Skeletons in composite materials for realization of pre-cast tunnel segments.
	RAAI	Whole Life Rail Axle Assessment and Improvement Using Ultrasonic Phased array and Corrosion Inspection Systems
	SafeTrain	Piloting and industrial validation of autonomous and sustainable animal deterring system

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		for the rail transport
	SDO-MET	Automatic Rail Safety Solution
	WARNTRAK	Rail track monitoring system - Wireless Autonomous On-Board System measuring vibration with continuous reporting to reduce maintenance costs and enhance reliability and safety.
2015	**SAFE-CTS**	Efficient and cost-effective intermodal road-rail container freight system
2016	**DIGITALIA 2**	Disruptive process for the construction of railway transition zones, reducing drastically construction and maintenance costs
	Greenrail	Greenrail, innovative and sustainable railway sleepers: the greener solution for railway sector
	ITECCO Demo	Demonstration and market replication of Innofreight's innovative rail logistics equipment for the raw material supply of the steel industry
2017	**Andromeda**	Predictive Maintenance for railway switches. Smart sensor networks on a machine learninganalytics platform
	DINTRA	Innovative railway sleeper design increasing track lateral resistance, reducing significantly costs related to track misalignment events
	DTD SYSTEM 2	A disruptive innovation for the minisation of railway mantenance costs
	FAST-TRACKS	Fast rAdio technologieS for uninterrupTed TRAin to traCKside communicationS
	NYSMART	Novel dual-fuel system for modernisation of air-polluting diesel locomotives to clean and efficient gas operation
	SAFTInspect	Ultrasonic inspection solution for railway crossing points
	tCat	Disrupting the rail maintenance sector thanks to the most cost-efficient solution to auscultate railways overhead lines reducing costs up to 80%

FAST TRACK TO INNOVATION

YEAR	ACRONYM	TITLE
2015	**AutoScan**	AutoScan – Rail inspection by autonomous systems
	FUTURA	FUTUre RAil freight transport: cost-effective, safe, quiet and green!
	NEOBALLAST	New high-performant and long-lasting ballast for sustainable railway infrastructures
	VA-RCM	Innovative Product for train door condition monitoring based on vibration analysis algorithms
	WheelWatcher	Advanced wheel measuring system for greater rail sector's profitability

H2020 - EXCELLENT SCIENCE: Marie Skłodowska-Curie actions

YEAR	TYPE	ACRONYM	TITLE
2014	IF	**ECDCOP**	Evolutionary Computation for Dynamic Constrained Optimization Problems
2015	IF	**LiftTrain**	Aerodynamic Lift force of Trains subjected to cross winds—get it right!
	RISE	**RISEN**	Rail Infrastructure Systems Engineering Network
2016	IF	**AMONTRACK**	Acoustic monitoring of railway track quality
	IF	**BioRail**	Biocementation for railway earthworks
	ITN	**ICONIC**	Improving the crashworthiness of composite transportation structures
	ITN	**SMaRT**	Sand Mitigation around Railway Tracks
	ITN	**SMARTI ETN**	European Training Network on Sustainable Multi-functional Automated Resilient Transport Infrastructures.

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	IF	**TRANSRISK**	Vulnerability and risk assessment of transportation systems of assets (SoA) exposed to geo-hazards

H2020 - APPLICATIONS IN SATELLITE NAVIGATION

YEAR	ACRONYM	TITLE
2014	**ERSAT EAV**	ERTMS on SATELLITE – Enabling Application Validation
2015	**RHINOS**	RHINOS - Railway High Integrity Navigation Overlay System will define a GNSS-based system to support the localization of trains respecting the challenging requirements of the railway safety standards.
	STARS	Satellite Technology for Advanced Railway Signalling
2017	**ERSAT GGC**	ERTMS on SATELLITE Galileo Game Changer
	SIA	System for vehicle-infrastructure Interaction Assets health status monitoring

H2020 - INDUSTRIAL LEADERSHIP: Leadership in enabling and industrial technologies (LEIT)

YEAR	ACRONYM	TITLE
2014	**I-ALLOW**	Imaging analysis in all lighting and off weather conditions
	INTO-CPS	INtegrated TOol chain for model-based design of CPSs
2015	**SAFEPOWER**	Safe and secure mixed-criticality systems with low power requirements
2016	**DEIS**	Dependability Engineering Innovation for CPS - DEIS
	TT	Transforming Transport

FACTORIES OF THE FUTURE PUBLIC PRIVATE PARTNERSHIP

YEAR	ACRONYM	TITLE
2016	**MAESTRO**	Modular laser based additive manufacturing platform for large scale industrial applications
2017	**RECOTRANS**	Integrated manufacturing of REciclable hybrid metalthermoplastic COmposites for the TRANSport sector.

5G INFRASTRUCTURE PUBLIC PRIVATE PARTNERSHIP

YEAR	ACRONYM	TITLE
2017	**5G-PICTURE**	5G Programmable Infrastructure Converging disaggregated neTwork and compUte REsources

ECSEL JOINT UNDERTAKING

YEAR	ACRONYM	TITLE
2015	**ENABLE-S3**	European Initiative to Enable Validation for Highly Automated Safe and Secure Systems
2016	**WInSiC4AP**	Wide band gap Innovative SiC for Advanced Power

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6.4 Questionnaire to European rail Sector Associations partners of TER4RAIL

TER4RAIL – WP1: Rail Innovative Research Observatory

TER4RAIL Project (S2R-OC-IPX-02-2018 www.ter4rail.eu) aims to **reinforce the cooperation between rail-related stakeholders** to improve the efficiency of the consensual exploratory research across the rail sector, in order to facilitate emerging innovative ideas and the cross-fertilisation of knowledge from other disciplines or of disruptive technology and innovation. TER4RAIL intends to promote this process by **strengthening transversal exploratory research in Europe** for and with a railways perspective.

As part of WP1: "**Rail Innovative Research Observatory**", project partners work on the **identification of non-rail actors** that may influence or foster innovative rail research and engaging with them in order to understand the way in which the activities of these stakeholders could be beneficial and nourish innovation though the railway sector.

In order to expand the outreach and ease the contact with stakeholders from other sectors, the focus has been put on non-rail European Technology Platforms and Partnerships officially recognised by the European Commission.

The current questionnaire, addressed to the following rail associations: UNIFE, UIC, UITP, EURNEX, NEWOPERA, partners of TER4RAIL project, has been prepared with the aim of gathering information on the interactions that are already taking place to make a better decision on the selection and approach of non-rail actors. It may be complemented by face-to-face discussions if needed.

Respondent :
Date :

The information contained in this questionnaire will be used by TER4RAIL project partners to support the elaboration of tasks 1.2. "Identification of non-rail actors and pool of expertise for the Rail Innovative Research Observatory" and 1.3. "Rail Innovative Research Observatory: Interacting, sharing experience, and effecting cross-fertilisation". The questionnaire will not be published as such, but the information provided will be used and presented in public documents.

Should you have any issue with the treatment of the information do not hesitate to let us know at the moment of providing the answers.

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COLLABORATION

Collaboration has proved to be crucial for research and innovation. TER4RAIL project is looking at how it takes place within the railway sector and with other sectors.

1. Which non-rail sectors is your organisation currently cooperating with on rail research and innovation related issues?
   -
   -
   -

2. Which sectors, with whom there is currently no cooperation, would your organization like to have future collaboration with on research and innovation issues?
   -
   -

3. There are currently 38 active **European Technology Platforms**, as recognized by the European Commission Could you please indicate from the list below which ones your organisation is already in contact with and the ones with whom your organization would be highly interested in developing collaboration in the future? *Use the color coding to answer the question.*

Bio-based economy	**Environment**	**ICT**	**Production and processes**	**Transport**
European Aquaculture TP (EATIP)	European Water Plaform (WssTP)	ARTEMIS Industry Association	European Construction, built environment and energy efficient building TP (ECTP)	Advisory Council for Aviation Research and Innovation (ACARE)
Farm Animal Breeding and Reproduction TP (FABRE TP)		ENIAC	European Steel TP (ESTEP)	ETP Alliance for Logistics Innovation through Collaboration in Europe (ALICE)
ETP 'Food for Life'		ETP on Smart System Integration (EPoSS)	ETP Advanced Engineering Materials and Technologies (EuMaT)	European Rail Research Advisory Council (ERRAC)

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Forest-based Sector TP (FTP)	ETP for High Performance Computing (ETP4HPC)	ETP Fibres, Textiles, Clothing (FTC)	European Road Transport Research Advisory Council (ERTRAC)
Plants for the Future ETP	euRobotics [AISBL]	ETP Manufuture	TP Waterborne
TP Organics	New European Media Initiative NEM	ETP Nanomedicine	
	ETP Software, Services and Data (NESSI)	ETP Sustainable Mineral Resources (SMR)	
	ETP for Communications Networks and Services (Networld2020)	ETP for Sustainable Chemistry (SusChem)	
	Photonics 21		

Feel free to add comments regarding the ones you have highlighted:

4. As in the previous question, could you please indicate from the list below which **European Technology and Innovation Platforms (ETIPs)** your organisation has already contact with and the ones with whom your organisation would be highly interested in developing a collaboration? *Use the color coding to answer the question.*

   - ETIP Bioenergy: http://biofuelstp.eu/
   - ETIP Wind: https://etipwind.eu/
   - ETIP Deep Geothermal: http://www.geoelec.eu/etip-dg/
   - ETIP Ocean Energy: http://www.oceanenergy-europe.eu/
   - ETIP Photovoltaic (ETIP PV): http://www.etip-pv.eu/homepage.html
   - ETIP Renewable Heating and Cooling: http://www.rhc-platform.org/home/
   - ETIP Smart Networks for Energy Transition (SNET): http://etip-snet.eu/index.html
   - ETIP Sustainable Nuclear Energy (SNETP): http://www.snetp.eu/
   - ETIP Zero Emission Fossil Fuel Power (ZEP): http://www.zeroemissionsplatform.eu/

   Comments:

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5. Here below is provided the list of European partnerships, public-private partnerships and Future and Emerging Technologies Flagships. As in the previous two questions, could you please indicate from the list below which **partnerships** your organisation has already contact with and the ones with whom your organisation would be highly interested in developing a collaboration? *Use the color coding to answer the question.*

- Factories of the Future (FoF) https://www.effra.eu/factories-future
- Energy-efficient Buildings (EeB) http://e2b.ectp.org/
- European Green Vehicles Initiative (EGVI) https://egvi.eu/
- Sustainable Process Industry (SPIRE) https://www.spire2030.eu/
- Photonics (Photonics21) https://www.photonics21.org/
- Robotics (euRobotics) https://www.eu-robotics.net/
- High Performance Computing (ETP HPC) https://www.etp4hpc.eu/
- Advanced 5G networks for the Future Internet (5G) https://5g-ppp.eu/
- European Cyber Security Organisation https://ecs-org.eu/
- Big Data Value Association http://www.big-data-value.eu/

- Graphene FET Flagship https://graphene-flagship.eu
- Human Brain Project FET Flagship https://www.humanbrainproject.eu/en
- Quantum Technology FET Flagship https://www.quantera.eu / https://ec.europa.eu/digital-single-market/en/news/first-call-proposals-under-fet-flagship-quantum-technologies

- Innovative Medicines Initiative 2 (IMI2) https://www.imi.europa.eu/
- Fuel Cells and Hydrogen 2 (FCH2) https://www.fch.europa.eu/
- Clean Sky 2 (CS2) https://www.cleansky.eu/
- Bio-based Industries (BBI) https://www.bbi-europe.eu/
- Electronic Components and Systems for European Leadership (ECSEL) https://www.ecsel.eu/
- Shift2Rail (S2R) www.shift2rail.org
- Single European Sky ATM Research (SESAR) https://www.sesarju.eu/

Comments:

6. Could you please share examples of good practices related to collaboration / networking / cross-fertilization that have proved useful for building the relationship with stakeholders on rail research and innovation issues?(i.e collaborative projects, workshops or seminars, technical meetings…)

With rail stakeholders

_____

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_____

With non-rail stakeholders

_____

_____

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NEW INNOVATIVE TECHNOLOGIES

TER4RAIL Survey participants were asked to write down the three most promising technologies or innovations that have the potential to transform the rail sector in the next 5 years / in the coming decades. The aggregated results obtained are shown below:

… in the next 5 years	
Digitalisation	10
Materials	8
5G	5
Automation	5
Batteries	5
Big Data	5
Energy	5
Condition based maintenance	4
Artificial Intelligence	3
Building Information Modelling - BIM	3
Automatic Train Operation	2
Augmented Reality	2
Block Chain	2
Communications	2
Internet of Things	2
Monitoring technology and sensoring	2
Power sources	2
Signalling technology	2

…in the coming decades	
Digital transformation	10
Materials	7
Artificial Intelligence	6
Automation	5
Autonomous mobility	5
Power sources	5
Hyperloop	4
Big data	3
Energy	3
5G Wireless connectivity	2
Condition monitoring & predictive maintenance	2
Environment necessities	2
Internet of Things	2
Nanotechnology	2

7. Is this in line with the research and innovation strategy of your organisation? Feel free to comment.

8. What are from your point of view the most promising technologies or innovations that have the potential to transform the rail sector **in the next 5 years**? *Please indicate the Top 3*

   1._____
   2._____
   3._____

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9. What are from your point of view the most promising technologies or innovations that have the potential to transform the rail sector in the **coming decades**? *Please indicate the Top 3.*

   1._____
   2._____
   3._____

10. Could you please indicate if your organization is working on **digitalisation** of the railway systems *(e.g. projects, initiatives, meetings, publications, working groups, etc.)?* Feel free to attach supporting documents.

11. Is your organization working on **materials** for research and innovation in railways *(e.g. projects, initiatives, meetings, publications, working groups, etc.)?* Feel free to attach supporting documents.

12. Is your organization working on **automation** for research and innovation in railways *(e.g. projects, initiatives, meetings, publications, working groups, etc.)?* Feel free to attach supporting documents.

13. Are there any other **new innovative technologies** not included in the list that you may consider relevant?

14. Could you please share examples of **good practices** related to the adoption or preparation for the challenges set by **new innovative technologies** on rail research and innovation issues?

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PROJECTS

One of the activities of TER4RAIL is the identification of rail related projects financed by Horizon2020. The following are the financing programmes / calls in which rail related projects have been identified:

- Shift2Rail Joint Undertaking - *Call for Members: 27 projects; Open Calls: 36 projects*
- Societal Challenges
  - Smart, green and integrated transport - *27 projects*
  - Secure societies - protecting freedom and security of Europe and its citizens – *4 projects*
  - Secure, clean and efficient energy - *1 project*
- Excellent Science – Marie Skłodowska-Curie Actions - *9 projects*
- Applications in Satellite Navigation - *5 projects*
- Industrial Leadership - *5 projects*
- SME Instrument - *55 projects: 38 Phase I; 17 Phase II*
- Fast Track to Innovation - *5 projects*
- Factories of the Future PPP – *2 projects*
- 5G Infrastructure Public Private Partnership – *1 project*
- ECSEL Joint Undertaking – *2 projects*

https://ter4rail.eu/2019/04/11/rail-project-scan/

15. Does your organisation have a specific interest in getting more information on the type of rail-related projects financed by any of these areas of H2020? Please indicate which ones and the type of interest.

Are there any other calls / projects / programmes that may be of interest to your organisation?

16. Is there anything else you may be interested in in relation to TER4RAIL Project?