MULTI - ANNUAL ACTION PLAN

EXECUTIVE VIEW

PART A

EXECUTIVE SUMMARY

Why act now?

Transport is the backbone of the European economy, bringing growth, jobs and prosperity. For example, railway transport-related products account for more than 20% of EU exports of goods and 8% of EU exports of services. For centuries, the railway has been the backbone of transport, instrumental in the different industrial revolutions.

With the evolving societal challenges, the other modes of transport have overshadowed the intrinsic attractiveness and competitiveness of the rail transport mode.

Today, although the railway remains at the heart of transport, it needs radical change to bring back its unique role to the forefront and as a backbone of future digital sustainable mobility-to meet the expectations of citizens, to connect people, business, and regions, and to make Europe a global hub for mobility and prosperity.

The 2015 Shift2Rail Master Plan (S2R MP) identifies eight key challenges being faced by the European Rail sector:

- Strengthening the role of rail in the European transport system and the global competitiveness of European industry;
- Quality of service;
- Cost;
- Integrating the European market;
- Infrastructure;
- Competitiveness;
- Skills;
- Innovation.

These challenges and the S2R vision offer a unique set of opportunities to the railway sector to radically transform and re-affirm its key role.

What is in the S2R Master Plan and the S2R Multi-Annual Action Plan?

The S2R MP provides a high-level view of what needs to be done; it explains why and by when. It sets the framework for the research and innovation (R&I) activities to be performed within and beyond the S2R Programme[1] and the deployment activities to be carried out by all operational stakeholders, coordinated to achieve the Single European Railway Area.

The present Shift2Rail Multi Annual Action Plan (MAAP) translates the S2R MP into detailed, result-oriented R&I activities to be performed to start delivering the S2R vision as from 2014 onwards.

*The **vision** of the S2R Partnership is*

TO DELIVER, THROUGH RAILWAY RESEARCH AND INNOVATION, THE CAPABILITIES TO BRING ABOUT THE MOST SUSTAINABLE, COST-EFFICIENT, HIGH-PERFORMING, TIME DRIVEN, DIGITAL AND COMPETITIVE CUSTOMER-CENTRED TRANSPORT MODE FOR EUROPE.

1 The S2R Programme runs between 2014 up to 2020 with the possibility of final implementation and phasing out by 2024.

Addressing the challenges opens three opportunities for the railway:

1. To become the backbone of current and future mobility concepts (e.g. mobility as a service-MaaS) and on-demand future logistics;

2. To identify and establish new market segments for exploitation;

3. To enhance the overall competitiveness of the industry, both in Europe and globally.

This is what Council Regulation No. 642/2014 tasks the S2R JU to do when requesting it to manage all rail-focused research and innovation actions co-funded by the European Union. More specifically, S2R seeks to develop, integrate, demonstrate, and validate innovative technologies and solutions that uphold the strictest safety standards and the value of which can be measured by the following key performance indicators:

- 100% increase in rail capacity, leading to increased user demand;
- 50% increase in reliability, leading to improved quality of services;
- 50% reduction in life-cycle costs, leading to enhanced competitiveness;
- removal of remaining technical obstacles holding back the rail sector in terms of interoperability and efficiency
- reduction of negative externalities linked to railway transport, in particular noise, vibrations, emissions and other environmental impacts.

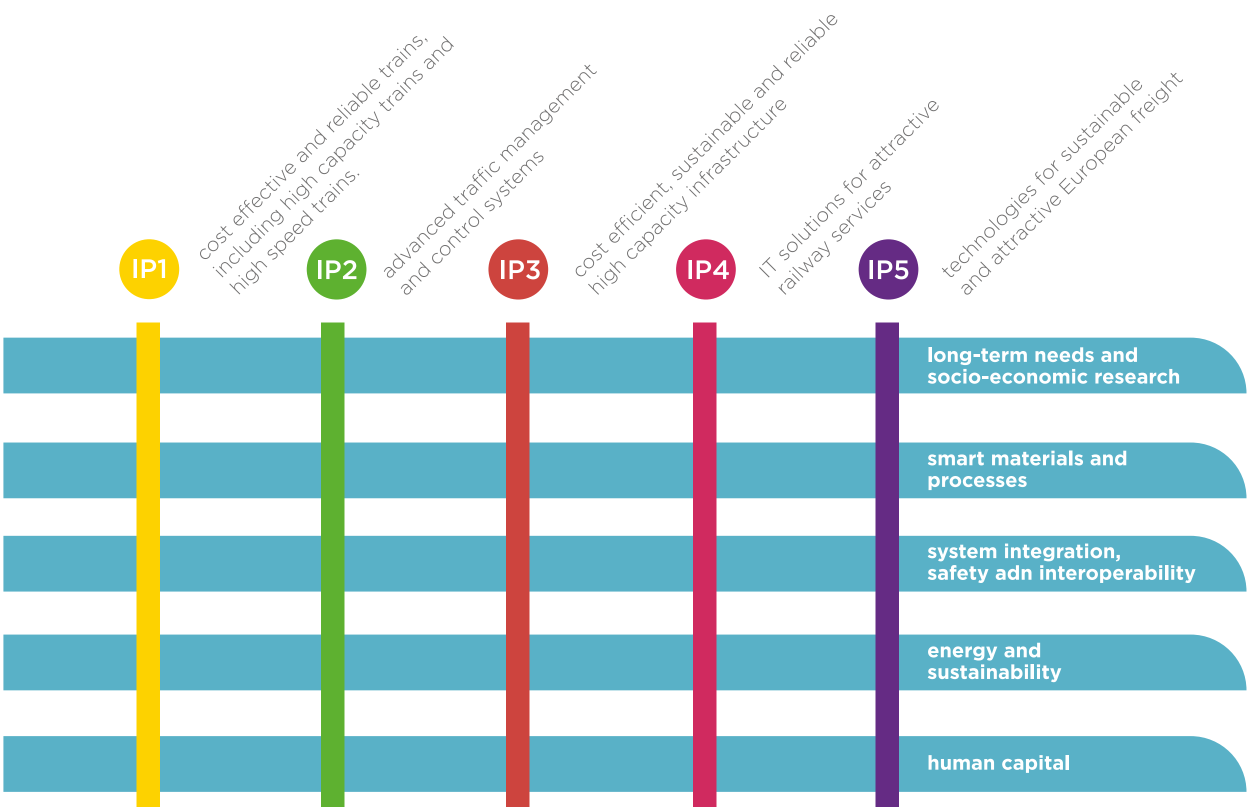
In order to realise its vision, the railway needs to establish and develop a range of new Innovation Capabilities (see Section 4). Developing the Innovation Capabilities requires a coordinated effort among different rail and non-rail stakeholders to drive innovation at many levels in Europe. The S2R JU and its Programme are designed to make a decisive contribution to delivering the essential knowledge and innovation that will provide the building blocks to develop the Innovation Capabilities.

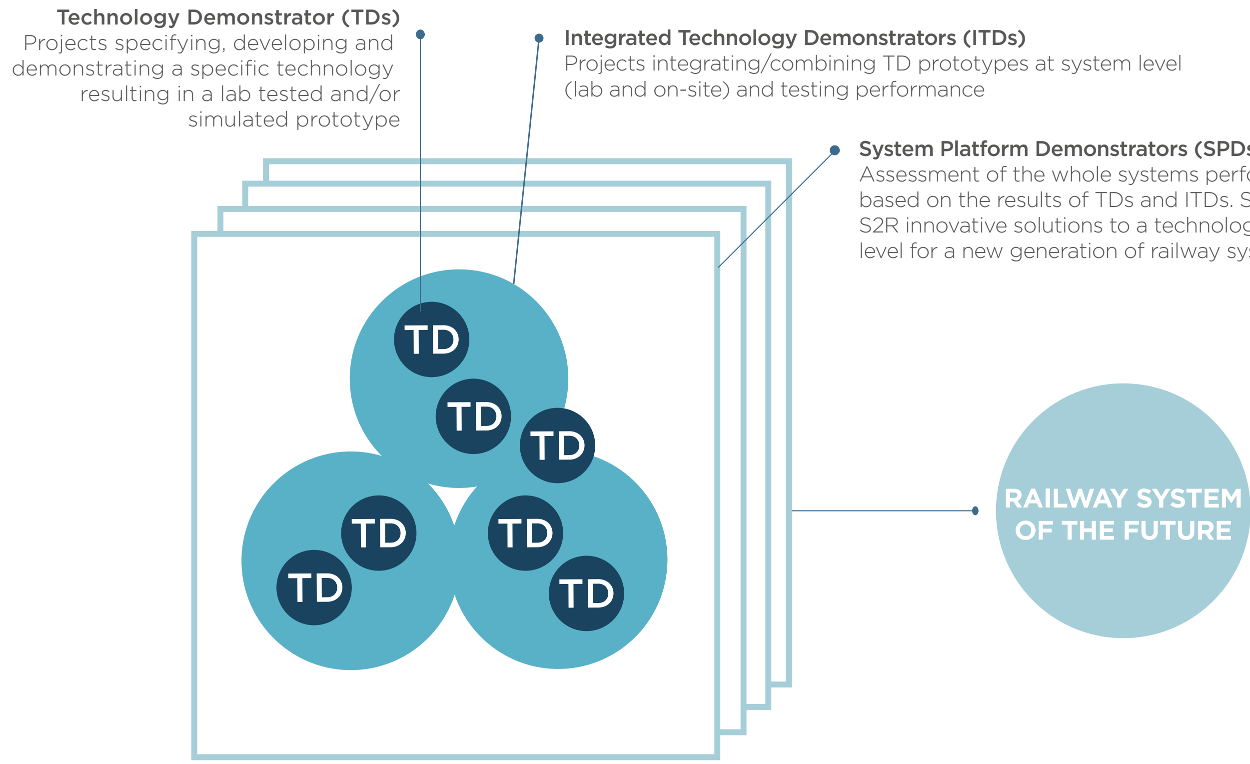
The work conducted within the S2R framework is structured around five asset-specific Innovation Programmes (IPs), covering the different structural (technical) and functional (process) sub-systems of the rail system. These five IPs are supported by work in five cross-cutting areas (CCA) covering themes that are of relevance to each of the projects and which address the interactions between the IPs and the different subsystems.

The practical demonstration of S2R R&I activities is being carried out using a combination of single technology demonstrators (TDs), integrated technology demonstrators (ITDs and the resulting Innovation Capabilities), and system platform demonstrators (SPDs).

By the end of 2017, EUR 333.2 million[2] has already been invested in R&I activities by the partnership.

[2] Including the Lighthouse Projects from the H2020 Transport Call 2014 awarded by the European Commission in 2015 and part of the S2R Initiative in accordance with the S2R Regulation for the amount of EUR 52 million..


IP1
cost effective 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 freight
long-term needs and socio-economic research
smart materials and processes
system integration, safety adn interoperability
energy and sustainability
human capital



What are the expected benefits?

Bringing about the technological and operational advances expected as a result of the S2R R&I activities requires active intervention. It does not happen by itself. Deployment of this complex array of innovation involves a coordinated effort to guarantee an adequate level of consistency and achieve the Single European Railway Area. This active role demands the capacity to recognise the steps required in the process, the funding needs, and the essential system of systems interaction and complexity of railway in all its segments and its components. This role should be as near as possible to the market while providing the necessary independence under a joint governance.

The benefits of reaching the S2R targets through focused and coordinated S2R R&I include, accordingly with the impact assessment[3] of the S2R Programme, the following economic benefits:

- An indirect leverage on industry R&I related to the development of industrial products exploiting H2020 innovations, worth up to EUR 9 billion in the period 2017-2023;
- Creation of additional GDP at EU level worth up to EUR 49 billion in the period 2015-2030, and spread among a large number of Member States;
- Creation of up to 140 000 additional jobs in the period 2015-2030;
- Additional exports worth up to EUR 20 billion in the period 2015-2030 thanks to the worldwide commercialisation of new rail technologies developed under H2020;
- Life-cycle cost savings worth around EUR 1 billion in the first 10 years and then, through continued implementation, worth around EUR 150 million per year.

[3] Impact assessment: Proposal for a Council Regulation establishing the Shift2Rail Joint Undertaking SWD (2013) 535 final, Brussels, 16.12.2013

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.

Securing the proper undertaking of such activities is therefore key both today and in the future in a market segment of major importance for the European Union, which today already provides 400 000 high-skilled jobs within European manufacturing industries, including numerous small and medium-sized enterprises (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.

In addition to the R&I Roadmap and to ensure a consistent deployment strategy, other key aspects involved in the way forward include placing innovation within a standards and regulatory framework, developing a credible business view, implementing an efficient risk assessment strategy, and establishing effective collaboration with other key organisations involved in the future of the European rail sector.

CONTENTS

1 INTRODUCTION

1.1. GENERAL POLICY CONTEXT

1.1.1. European strategic vision for an integrated transport system

The 2015 S2R MP describes a general policy context that remains relevant today. The European Commission is committed to a Europe 2020 strategy based on smart, sustainable, and inclusive growth. This includes achieving a more competitive and resource-efficient European transport system with a view to addressing major societal issues such as rising traffic demand, congestion, security of energy supply, and climate change.

To achieve this, the Commission's 2011 Transport White Paper ("Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system") sets out key goals to strengthen the role of rail in the transport system, given rail's inherent advantages in terms of environmental performance, land use, energy consumption, and safety.

A number of these goals (Table 1) relate specifically to rail passenger and rail freight transport, while others relate more generally to urban mobility, with an indirect impact on rail.

In 2016, the European Commission published a document reporting on the implementation pace of the 2011 Transport White Paper . This report highlights the relevance of the original targets, stressing the importance of taking into account rapid technological developments that are reshaping mobility concepts and opening potential new ones, particularly due to automation and digitalisation.

On 13 September 2017, the European Commission published its Communication "Investing in a smart, innovative and sustainable Industry - A renewed EU Industrial Policy Strategy" adding a pillar to move from R&I to deployment:

> "*Progress is needed at all levels to ensure that our regulatory frameworks provide the necessary flexibility to allow innovation to develop. We must learn to consider the perspective of innovators as they often have less of a voice than incumbents. To this end, the Commission will apply the innovation principle through its Better Regulation Agenda. The innovation principle entails taking into account the impact on research and innovation in the process of developing and reviewing regulation in all policy domains, i.a. to ensure that EU regulation allows companies to enter markets more easily.*"

Transport White Paper goals related to rail	
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
	Rail freight should be almost doubled adding 360 billion tonne 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 CO_2-free city logistics in major urban centres by 2030
	By 2020, establish the framework for a European multimodal transport information, management and payment system

Table 1. Summary of rail-related goals in the Transport White Paper

[4] http://ec.europa.eu/transport/sites/transport/files/modes/rail/doc/2015-03-31-decisionn4-2015-adoption-s2r- masterplan.pdf6.

[5] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0144&from=EN

[6] SWD (2016) 226 final, Brussels, 1.7.2016. The implementation of the 2011 White Paper on Transport "Roadmap to a Single European Transport Area – towards a competitive and resource-efficient transport system" five years after its publication: achievements and challenges.

[7] COM (2017) 479 Final of 13 September 2017.

1.1.2. Reindustrialisation

The S2R JU also has an important role in supporting the European Commission's policy on reindustrialisation[8], which recognises the central importance of industry in creating jobs and growth to recover from the recession, and espouses a target that industry should generate as much as 20% of Europe's GDP by 2020. By leveraging technical innovation and transforming its performance, S2R will enable the rail sector to be a key part of this enhanced European industrial competitiveness.

1.1.3. The Single European Rail Area (SERA)

As indicated in the S2R MP, the 2011 White Paper points out that the creation of a Single European Railway Area (SERA) is crucial to achieving a modal shift from road towards more sustainable modes of transport such as rail. In fact, this could serve to dramatically cut the costs of running passenger and freight trains by providing a common framework of rules and regulations for rail operators in the Member States. While urban rail is excluded from the scope of SERA, this goal remains as relevant today as it was then for all rail systems.

Since the adoption of the 2011 White Paper, a lot of progress has been made towards the goal of creating the SERA. The agreement on the 'rail recast'[9] considerably changes the way the rail market works by stimulating investment, improving market access conditions, and strengthening the role of national rail regulators.

The recast has also paved the way for the major legislative proposals that together form the Fourth Railway Package, without which the European single market cannot be complete. This set of legislation, adopted in 2016 , aims to remove remaining administrative, technical, and regulatory obstacles that are holding back the rail sector in terms of market opening, competitiveness, and interoperability.

These issues are being addressed by the different initiatives in three main domains:

- Domestic passenger market opening – opening domestic rail passenger markets to competition, including open access lines as well as the routes under Public Service Obligations;
- Infrastructure governance ensuring that infrastructure managers perform a consistent set of functions that optimises the use of infrastructure capacity, and that its organisation guarantees non-discriminatory access to the infrastructure and rail related services;
- Interoperability and safety removing remaining administrative and technical barriers, in particular by establishing a common approach to safety and interoperability rules to decrease administrative costs, to accelerate procedures, to increase economies of scale for railway undertakings, and to avoid disguised discrimination.

Full implementation of this package should allow significant savings on both administrative and running costs for train manufacturers, operators, and national regulators, while also helping new entrants into the marketplace, thereby enhancing the quality and efficiency of rail services.

In addition, the Fourth Railway Package recognizes the S2R contribution to:

> “*Developing rail as a transport mode by promoting step-change innovations for passenger rolling stock, freight transport, traffic management systems and rail infrastructure*”

8 Communication For a European Industrial Renaissance (Jan 2014)

9 Directive 2012/34/EU of the European Parliament and of the Council of 21 November 2012 establishing a Single European Railway Area (recast)

10 The “Technical Pillar” was adopted by the European Parliament and the Council in April 2016; the “Market pillar” in December 2016. For more information, please refer to: https://ec.europa.eu/transport/modes/rail/packages/2013_en

1.2. ABOUT THE MAAP

This document (Part A) provides an executive view of the updated MAAP, clarifying the S2R vision and its contribution to delivering European Union societal goals. It identifies the associated set of twelve new capabilities (Innovation Capabilities) S2R will help the railway develop and bring to market. It describes the S2R Programme as a whole-summarising its purpose, structure, methodology, and content—and focuses on the series of intermediate steps by which it will bring about a radically improved railway system (urban/suburban, regional and high-speed passenger rail, freight), shaping the future mobility of people and business. These steps will be taken through the development and implementation of the R&I activities planned in the MAAP, while capturing new technologies and following a Europe-wide system of systems approach that is novel for the sector.

Part A links the S2R MP[11] and the MAAP as indicated below (Fig. 1).

It explains how the MAAP and its detailed activities (as set out in Part B), within the framework of the original S2R MP, are designed to deliver the vision of a radically-improved railway system. It also explains the opportunities that this could bring to the railway industry and to society as a whole.

The Innovation Capability delivery strategy and associated implementation plan require full cooperation between all stakeholders to prioritise and align efforts and resources.

The fundamental rationale of this process is illustrated in Fig. 2.

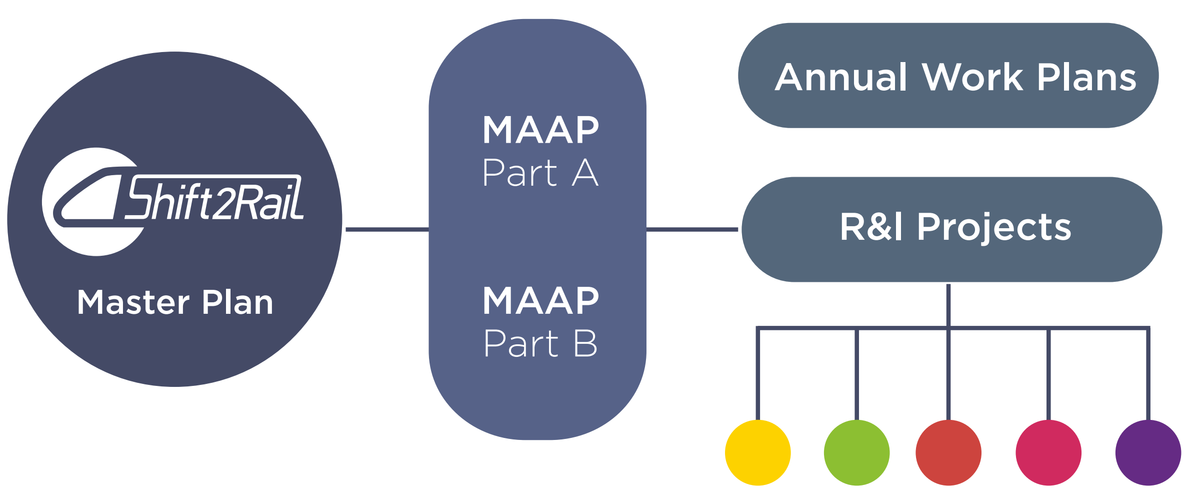


Fig. 1. Shift2Rail framework

[11] Approved by the S2R JU Governing Board on 24 September 2015 and endorsed by the Council on 10 February 2015 (Decision on the adoption of S2R master plan No 4/2015)

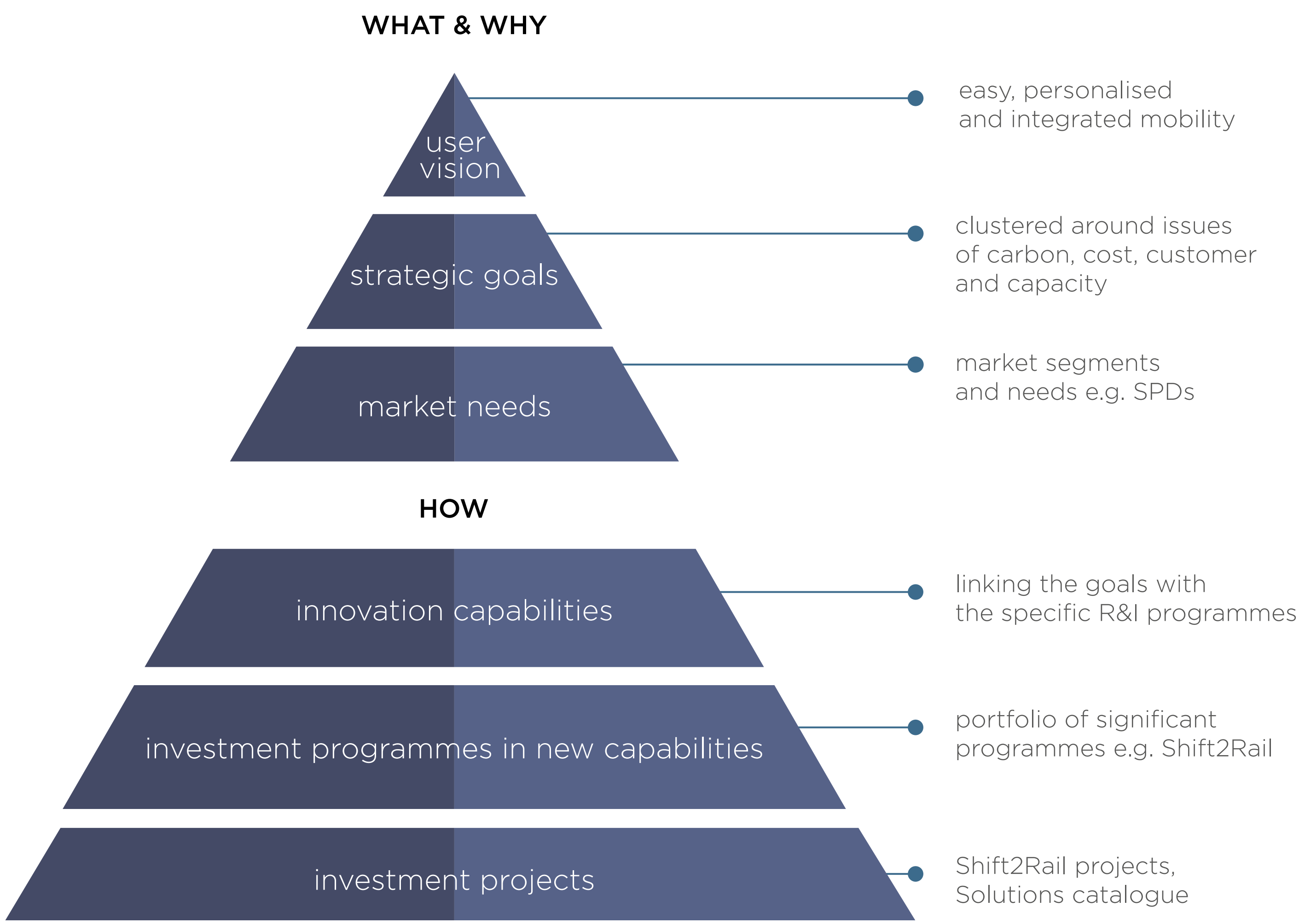


Fig. 2. Vision and strategy structuring principles

2
CHALLENGES AND OPPORTUNITIES

2.1. KEY CHALLENGES FOR THE EUROPEAN RAIL SECTOR

The S2R MP identifies eight key challenges faced by the European rail sector (Fig. 3). If not addressed, these challenges will have an adverse effect on the continuous development of rail as a competitive transport mode and on European rail manufacturing industry competitiveness in the global market. However, they also offer a unique set of opportunities for the sector to expand and re-affirm its role.

Fig. 3. Eight key challenges faced by the European Railway sector

2.2. KEY OPPORTUNITIES FOR THE EUROPEAN RAIL SECTOR

The railway sector already has a range of advantageous characteristics which sets it apart from its competitors—for instance, its ability to provide mass transit, journey comfort, safety, reduced land use, a low carbon footprint, and energy efficiency—although in some areas, other modes of transport are rapidly catching up (automation, lower carbon footprints, etc.). By addressing the challenges identified above, it can open three areas of opportunity (Fig. 4):

1. Becoming the backbone of mobility as a service and on-demand future logistics;

2. Identifying and establishing new market segments for exploitation;

3. Enhancing the overall competitiveness of the sector, both in Europe and globally.

Opportunity 01_ Passenger and logistics core provider for mobility services.

Digitalisation and the rapid development of new technologies are unlocking a radically different approach to mobility, superseding modally-based structures and facilitating the provision of seamless travel, with mobile devices as one of the key instruments. This creates an opportunity to capitalise on the strengths of the railway-e.g., mass transit capacity, comfort, and high energy efficiency-by integrating it with services covering the first and last miles to offer door-to-door mobility for people and goods. The digitalisation process also creates an opportunity to achieve transformative integration of the sub-systems that make up the railway.

This opportunity calls for tackling the challenge of completing the integration process and specifically the set of rules and instruments needed to achieve an efficient integrated operation of a single shared European rail system, allowing urban, regional, and national systems to become part of a broader European mobility system with all the benefits that this brings.

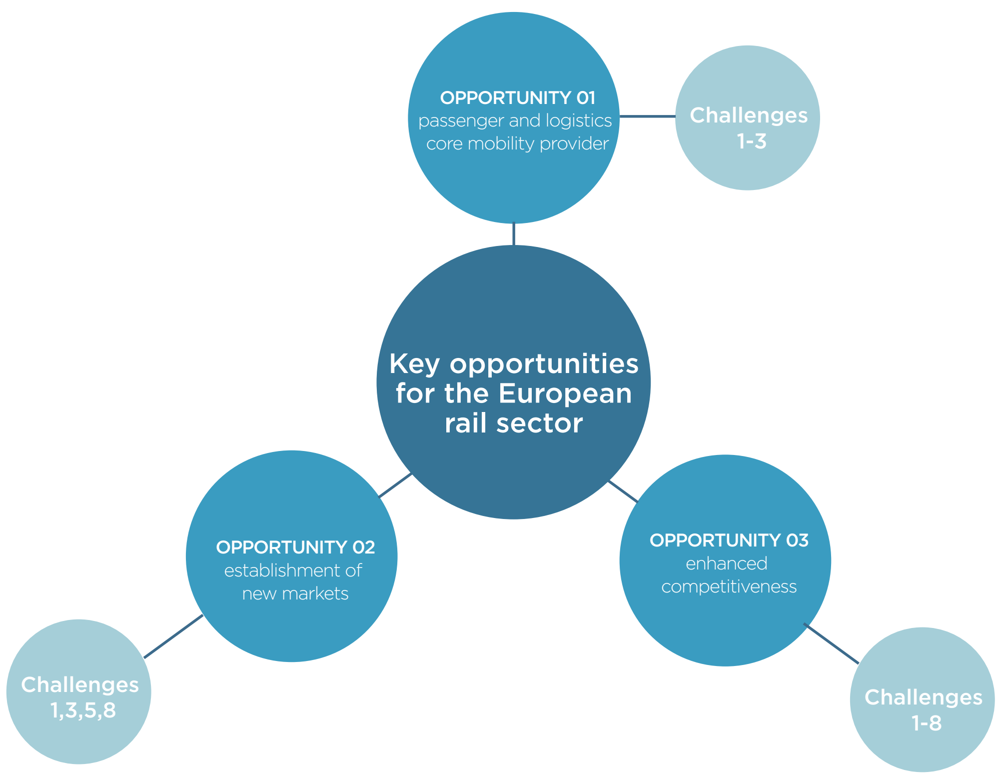


Fig. 4. Main opportunity clusters for the European Railway sector

Opportunity 02_ Establishment of new markets.

Digitalisation, new technologies, innovation, and a need to increase efficiency at all levels create an opportunity for the railway to exploit its assets and strengths to open new markets and services to the benefit of the final user and EU citizens. It can produce unique opportunities that exploit underused capacity and network branches in new ways, e.g. closed or low traffic regional lines. This is also linked to diminishing societal support for large transport infrastructure projects, given the high levels of investment required and the dominance of the cost-benefit assessment approach in public office that tends to overlook the many advantages offered by modes such as rail. This is particularly relevant in the freight and high-speed segments.

Opportunity 03_ Competitiveness.

The opportunities that the digitalisation process and rapid technological innovation deployment bring can have a deep effect on enhancing competitiveness in various key areas- e.g. products and system solutions, skills, cost optimisation, improved manufacturing, new markets, boosted productivity, and performance.

Similarly, a more competitive rail system can also contribute to increasing the competitiveness of the European economy by facilitating higher productivity rates, translating into jobs and advancement of the prosperity prospects of its regions and citizens.

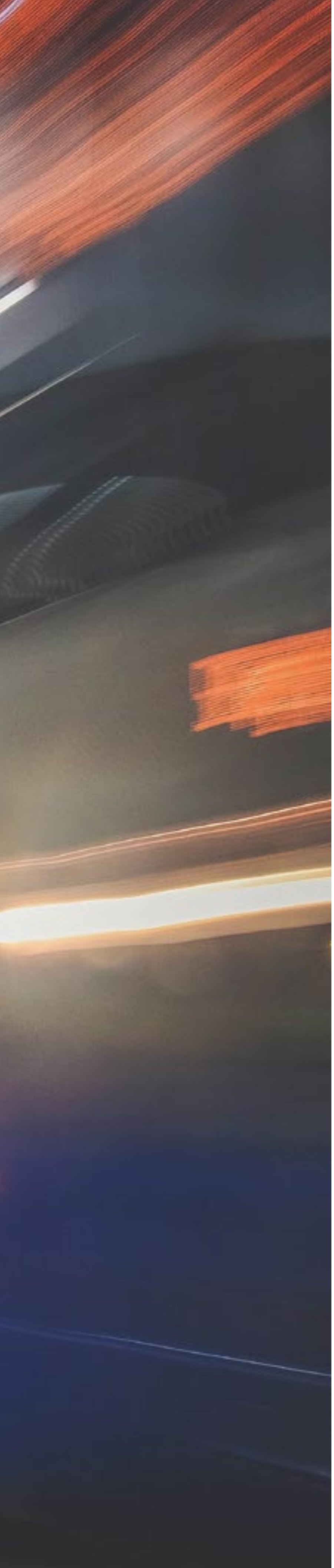
Through the S2R R&I Programme, the European rail supply industry can create new business opportunities that:

- Contribute to macro-economic benefits such as
  - gains in employment quantity and quality,
  - improved productivity,
  - rise in net exports,
- Address and correct existing inefficiencies, e.g.
  - low levels of collaboration between stakeholders,
  - lack of true Europe-wide systems approach,
  - lack of investment for high risk research,
  - difficulty of introducing new solutions as they are only tested in service in specific and willing clients' projects.

A COMPETITIVENESS IMPROVEMENT THROUGH A SKILLS DEVELOPMENT APPROACH CREATES AN OPPORTUNITY TO ENGAGE WITH DIVERSE YOUNG CITIZENS

A competitiveness improvement through a skills development approach creates an opportunity to engage with diverse young citizens to attract them to the industry through the development of appealing, interesting, and fulfilling engineering education programmes supported by stakeholders (e.g. sponsorship and apprenticeship schemes). In addition, educational training opportunities for the existing workforce allow for the development of the necessary skills to adapt to the fast-paced and complex technological changes in the sector. Furthermore, the already-advanced global standing and reputation of the European sector offers the opportunity to export the European model and vision to other markets. Similarly, a competitive and skilled European sector can transfer its knowledge to other sectors and benefit from them (e.g. automation and electrification of roads).

Rail's inherent characteristics and advantages at the core of its competitiveness provide a unique opportunity to meet the global demand for increased sustainability, particularly in the context of rising demographic challenges and fast urbanisation. To achieve the whole potential that this opportunity brings, a strategy is needed that enhances the performance through innovation in environmental aspects, safety, and efficiency.



3

THE S2R VISION

TO DELIVER THROUGH RAILWAY RESEARCH AND INNOVATION THE CAPABILITIES TO BRING ABOUT THE MOST SUSTAINABLE, COST-EFFICIENT, HIGH-PERFORMING, TIME DRIVEN, DIGITAL AND COMPETITIVE CUSTOMER-DRIVEN TRANSPORT MODE FOR EUROPE.

Key features of this vision are set out below, highlighting the characteristics of the customer-driven rail transport mode:

1. It is **available seven days** a week and is **reliable, resilient, safe and sustainable**
2. A **whole-system approach** across the industry **fosters innovation** and attracts the **best talent**. **Entrepreneurs and innovators** have the **right conditions** to develop new products and services.
3. **Network capacity** is optimised to meet all requirements for passengers and freight. **Intelligent maintenance** increases train and track availability and reduces perturbations and delays. World-class asset management is aligned across the industry to **improve performance**, **lower costs and reduce business risks.**
4. Flexible, real-time **intelligent traffic** management and in-cab signalling reduces headways and decreases traction energy consumption. Control centres know the precise location, speed, braking and load of every train on the network to **optimise operational performance and keep passengers informed.**
5. **Carbon emissions are minimised** by widespread electrification of the network and sustainable, energy-efficient solutions for the remaining non-electrified routes. Energy recovery systems in rolling stock and alternative fuels allow trains to lower costs and run on and off the electrified network. **Sustainable Development Principles** are **embedded** in the design, construction and operation of infrastructure and rolling stock assets and the railway is resilient to climate change.
6. The **industry** is increasingly **cost-effective** as more efficiencies are introduced. Unplanned maintenance and damage to track and train are minimised through enhanced industry-wide condition monitoring. Generic designs for buildings and rolling stock interfaces are used instead of costly bespoke solutions to simplify expansion, upgrades and replacements.
7. **Operational and customer communications** are supported by equipment that can be updated with **plug-and-play fitments**. Rail services are **integrated** with other transport modes so that passengers have **seamless door-to-door journeys**.
8. **Station information systems and personalised messaging** offer passengers all the relevant information to travel **easily and reliably** to their destinations. **Passenger-friendly stations eliminate** the need for queues or physical **barriers**. Revenue collection and security are based on electronic systems
9. An **extensive high-capability strategic freight network** with increased route availability provides freight customers with flexible and timely responses to their operational and planning requests.

Central to this vision is putting the customer in charge. This is the opportunity to deliver to European citizens the benefits of "disruptive change," from today's railway transport, operations and capabilities, to a user-centric railway system that excels itself.

The S2R Partnership, reflecting the rail sector's good understanding of its customers' personalised requirements, is working towards delivering the major part of a mobility system which combines and integrates the best from all transport modes to provide optimal services for people and goods.

Rail, already central to the market segments it serves, will become further integrated into this mobility system, thereby contributing more than the benefits it provides on a stand-alone basis-e.g., mass transit, transport of heavy loads, and efficient use of space.

[12] S2R partnership includes also the different S2R advisory bodies and working groups.

3.1. ADDRESSING KEY SOCIETAL TRENDS

S2R is being established within the context of a Europe experiencing important societal and other key changes. Of these 'megatrends,' those identified by the European Environmental Agency as most affecting the railway are digitalisation, urbanisation, and aspects of climate change. Another key societal trend in Europe is the increase in the average age of the population. The S2R vision therefore considers these and responds to them

Digitalisation

Arguably, the single greatest societal impact of recent decades has been the transformation wrought by digital technology. Digital connectivity is changing the game, and its continued development has expanded the demand for mobility. User's openness to, and uptake of, new solutions and innovations has increased, and there is an overall boost to social and economic activity which is leading to an increased demand for travel and distribution. S2R will harness the capabilities of the digital revolution to provide a transformed mobility system: in its design, delivery, and availability to all users. This approach is not about digitalisation of the current processes and procedures; it is the way industry, businesses, and the railway system will take the opportunity to look at how digitalisation applies to all steps of the value-chain: re-thinking and re-engineering business models to capture the full advantages of the present and future digital revolution. As the approach to connectivity, automation and digitalisation in the railway is part of the wider EU strategy, the key is not the development of a separate model but a clear S2R plan to implement it through research, innovation, and system architecture definition.

Urbanisation

For a long time, there has been movement in Europe away from rural areas to the cities for both work and permanent residence. This continuing trend has already seen a tipping point in mobility requirements, with new phenomena emerging, such as the reduction in private car ownership in favour of other arrangements (e.g., leasing, car-sharing, and Mobility as a Service), 24-hour intense living patterns, and readily-available information and services on-demand, anywhere, anytime. S2R's vision is to put in place a truly connected and permanently available mobility offer, meeting the needs of people and businesses. The railways already have a unique advantage through their capacity to move very large numbers of people, being able to provide tangible benefits to alleviate the urbanisation challenges. According to the Union Internationale des Transports Publics (UITP), each year European metropolitan metros carry 9.5 billion people and tram/LRT 8.5 billion, nevertheless accounting only for 6% of total urban mobility. Shift2Rail aims 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.

Climate change and the environment

Currently, railways have a good environmental performance, making only a marginal contribution to the transport sector's overall share of GHG emissions; however, as agreed at global level, further improvement is expected in line with the targets of COP21 . Noise also remains one of the key challenges that the railway system must address.

The S2R vision is to provide mobility with zero harm to the environment by adopting a system approach to managing the entire value chain and building on railway's existing strong track record in this area. The direction is towards a railway producing 'no carbon, no emissions, no noise'.

Further adoption by European citizens of an available, high-performing, and attractive renewed rail offer in their daily journey will automatically and significantly contribute to the European countries' achievement of COP21 targets.

Ageing population

The population of Europe is increasing overall-albeit divergently between regions-but almost everywhere the average age of citizens is increasing, as is the number of people with physical impairment to their mobility. Through its R&I, the S2R JU provides easy access to the rail system to achieve mobility for all people, including those who traditionally have found it difficult to use transport systems. This will provide freedom for all people to participate to the fullest extent in social and economic life, whatever their age or capabilities. In addition, the reliance on the use of technology as a means to deliver mobility needs to be addressed; information should arrive to the passenger whether he or she has access/ability or not to use personal smart devices.

[13] "Assessment of global megatrends - an update", European Environmental Agency (EEA), February 2017

[14] These eleven megatrends identified by the EEA cover social, technological, economic, environmental and political aspects, with digitalisation, urbanisation and climate change being the main mega-trends directly affecting the railway.

[15] Conference of Parties (COP) aims at adopting the convention of the UN Framework on Climate Change (UNFCCC). COP21 was the 21st event since Berlin 1995 and it took place in Paris in December 2015.

3.2. THE NEED FOR RADICAL TRANSFORMATION

In light of these megatrends, existing models of transport provision in Europe are under severe pressure; they need a paradigm shift to meet the evolving user requirements. For instance, infrastructure designed to provide a much lower level of capacity than that required for current demand is becoming a common barrier across all modes, which may lead to poor service quality. These risks are further restricting the economic development of regions and Europe as a whole, adding a significant cost burden for businesses and the distribution chain, reducing competitiveness in world markets, and hence failing to meet users' expectations. Fundamental changes to the models, based on technical and operational innovative solutions, is needed to address these challenges and specifically to create user-centric affordable mobility as a service which will underpin all aspects of life.

Nevertheless, different solutions are already coming to the market. Different appreciations of the "value of time" results in the proposal and usage of different mobility systems. For example, the use of long-range, low-cost, but time-consuming bus services meet the expectations and needs of some categories of passengers. At the same time, the use of the "trains as an office" answers to the needs of those passengers who value the journey as key personal time

Some transformational technologies are already being developed, capturing public interest and imagination, e.g. autonomous road vehicles. In the railway context, such applications have been in place for a long time-albeit mostly unnoticed to the public, there is autonomous train operation in almost 40% of the metro systems worldwide-but there is a need to develop and implement wider and more sophisticated applications for mainline operation.

In a context where current mobility models and paradigms are in a state of flux, S2R will provide new rail-based capabilities which leverage the rail sector's unique features, combining and integrating them with those of other modes to serve customers' mobility needs.

3.3. CUSTOMER-FOCUSED MOBILITY

So, what might this next generation system look like? Here is a description of the rail system of the future, utilising the products originating from the S2R Programme:

From a user perspective, there is confidence that whenever someone wants to go from A to B or goods needs to be delivered, it will be easy to obtain a service as soon as it is needed, travel in comfort securely and quickly, without needing to own or operate a vehicle and at an affordable price. The customer wants to receive the best possible service, and the use of their time is precious. The customer needs to be assured that all is going well, but also be able to re-specify the journey (e.g., destination) should circumstances demand. He/she is not very concerned about the technical arrangements underpinning the service, although may have a preference for certain service providers or set of services within a competitive market. Those services conform to standards allowing system-wide interoperability to minimise system costs while maximising their performance. The automated transits provide origin collection/destination delivery and combine this with a rail-based core land transport network and links to air and sea (combined transport).

The network allows the operation of automated, intelligent trains that respond dynamically to customer demand. Splitting and joining on the move provides maximum operational flexibility to meet customers' needs while maximising network utilisation. This results in much greater effective capacity than before, based on trains running closer together and more safely, so the customer does not suffer from traffic congestion. Journey durations are predictable and quick and digital connectivity allows users to do everything they can do at home/in the office and links to other services, e.g. on the train or at their destinations. In fact, the train can become an office-or even a playground.

For logistics and distribution, too, the experience is transformed, with the easing of congestion and removal of long queues of vehicles in traffic jams, currently a regular feature near towns, ports, motorways, and in bad weather. The new logistics-with next generation rail at its heart-always allows on-time delivery, security of supply, and lower inventory and therefore system costs. The customer choice for trains as a key mode of transport contributes to breaking down the barriers between the multiple modes needed to deliver goods. This is realised through synchronisation with train movements on the network and with the road mode in pre- and post-haulage, improved real-time information to customers, and better data exchange between involved parties in the intermodal transport chain.

This vision of the future railway depends on the S2R Programme delivering its goals.

4

A CATALOGUE OF RAILWAY INNOVATION CAPABILITIES

To take advantage of these opportunities and to realise its vision, the railway needs to put in place a range of new Innovation Capabilities. These will enable the sector to produce value-adding products and services. As an example, the capability to run trains much closer together would allow a dramatic increase in service frequency and network capacity, with higher system utilisation and related revenue adding significant value to railway businesses.

A catalogue of twelve Innovation Capabilities (Fig. 5) described below have digitalisation and automation at their core. They include one that is non-technical, yet vital for the others-focused on delivering the process of innovation itself-a capability to accelerate, develop, accept, and deploy innovative products and services. For each of these capabilities, a set of necessary intermediate competences and technological advances (sub-capabilities) is described.

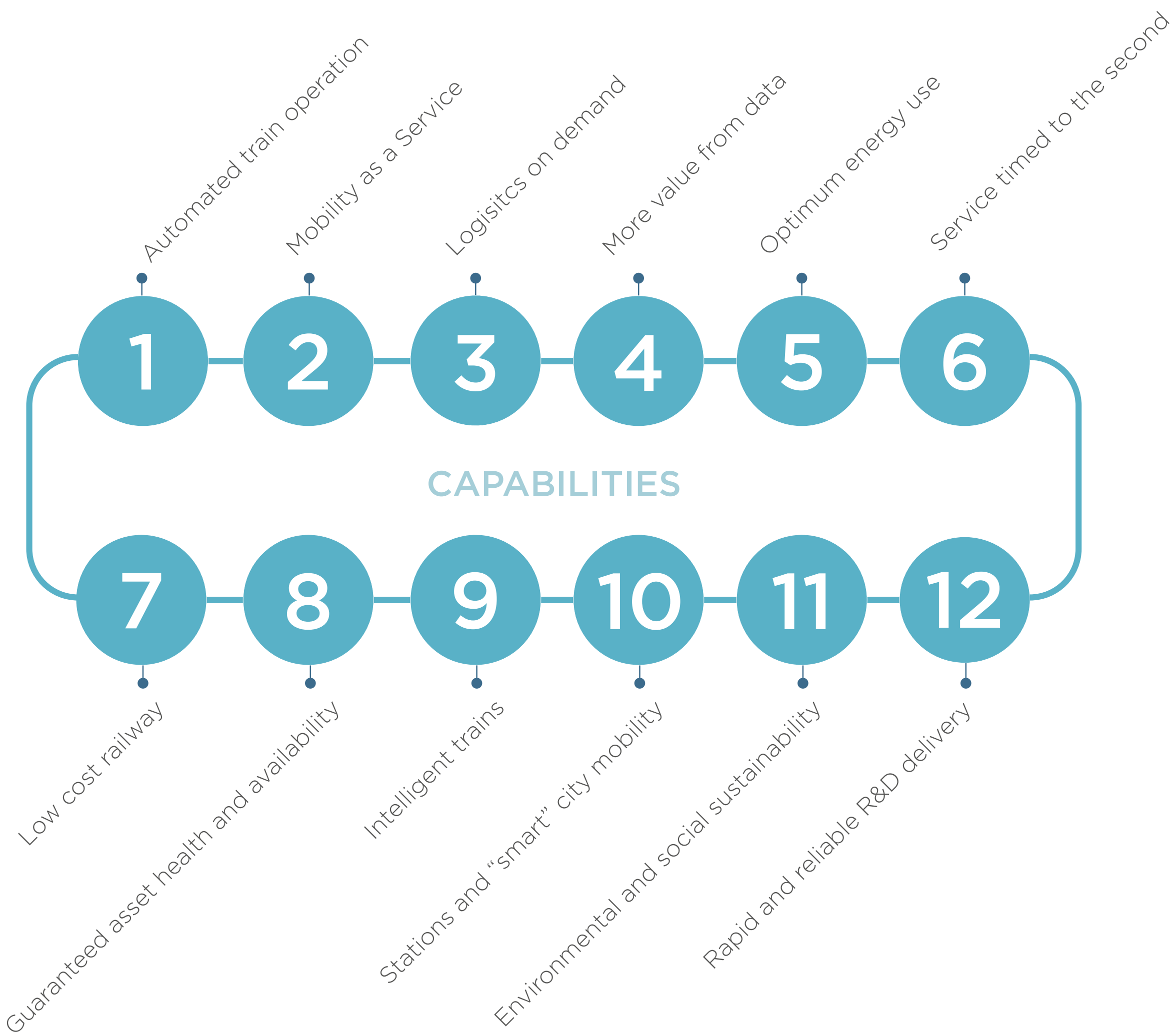


Fig. 4. Twelve capabilities required for the realisation of the Shift2Rail vision

[16] These capabilities have been developed in coordination with the UIC "Research and Innovation Coordination Group"

INNOVATION CAPABILITIES

#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. Autonomous and remote controls provide a safe operation. Rail operations are partly or fully automated.

1A Automated (passengers and freight) trains run closer together with increased flexibility.

1B Passenger and freight train preparation processes are automated.

1C Vehicles split and join on the move. New operational approaches (e.g., virtual coupling, convoying, reduced headway, communication connections between trains/units) are employed.

1D Self-propelled automated / autonomous single units guide themselves through the system.

#2 Mobility as a Service

Customer demand-driven services lead the railways to provide excellent service within the overall mobility chain. Connections between the railways and the other modes are seamless, making mode interchange as simple and as efficient as possible. Information is permanently available to make travel safe and efficient along the travel chain including at stations. All customers and potential customers are connected to mobility services.

2A Tailored guidance to the best use of available transport services is provided so that each customer appreciates a personalised service.

2B Every journey is provided intelligently and seamlessly, with rail physically integrated with the other modes.

2C Continuous flow of information eases the journey, making connections between the different modes seamless.

2D Electronic ticketing and payment are the norm.

2E Top-quality passenger experience and comfort are guaranteed as a key feature of the service.

#3 Logistics on demand

Logistics services are driven by customer demand, with freight moved reliably in flexible units designed to carry various loads. Better planning, tracking and shipment information capabilities combine to offer customers flexibility and capacity at reasonable, attractive prices. The rail system is fully integrated with the multimodal logistic chain.

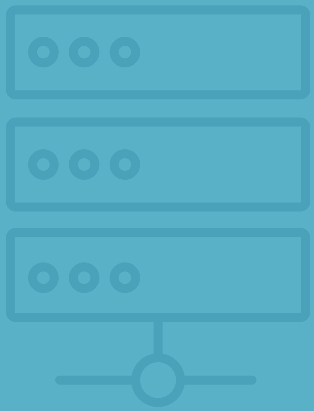
3A Planning and scheduling are synchronised in real-time to customer demand.

3B Flexible, interchangeable, multipurpose, and smart freight transport units increase handling flexibility and unit utilisation.

3C Shipments are moved effectively, efficiently, safely, and securely throughout the "physical internet" logistic chain.

3D Freight trains are able to integrate within high-intensity passenger operations.

3E Automated yards, intermodal hubs, ports, and cross-modal interchange locations connect the rail system into the multimodal logistic chain.



#4 More value from data

To deliver on all the capabilities, rail manages a growing volume of data contributing to the data economy. 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 a robust, resilient and secure information architecture and governance structure. Taking into account data privacy management, relevant information is shared across the industry and more widely, enabling the development of new services and applications to the benefit of the railway and its customers.

4A Secure, robust, scalable and resilient open architecture and protocols allow full interoperability.

4B The Internet of Things (IoT) and Artificial Intelligence (AI) provide efficient capture, storage, management and interpretation of data.

4C The customer and the rail system communicate intelligently with each other.

4D Railway businesses exploit new data-driven revenue streams.

4E Big Data analytics enables a range of new and improved services to be developed. State of the art cybersecurity ensures reliable and secure ICT services, protection of the rail system, and business continuity in case of an incident.

#5 Optimum energy use

Railways maintain their position as the most environmentally friendly mode of transport by decreasing energy consumption. This is achieved together with lowered operating costs through the use of an intelligent energy management system. The introduction of new technologies and methods as supporting tools enable reduced and optimised demand-led energy use and energy efficiency.

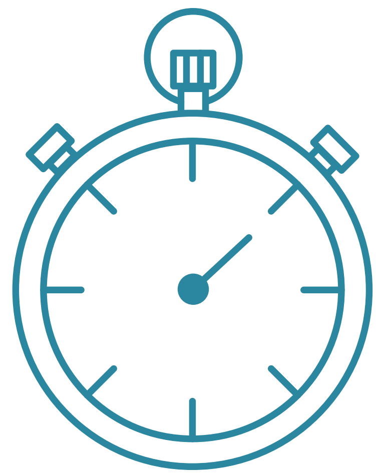
5A Alternative propulsion concepts such as fuel cells are introduced. Hybrid powertrains allow running over non-electrified track sections. Discontinuous electrification at stations and on branch lines dramatically reduces the capital costs of extending electrification.

5B Automated Train Operations (ATO) improves energy efficiency.

5C Optimised on-board and line-side energy storage and charging technologies (e.g. dynamic wireless power transfer) allow the railway to redistribute energy throughout the system according to supply and demand.

5D A high proportion of energy is recovered through regenerative braking, and small scale energy generation and harvesting technologies feed energy efficient trackside systems.

5E A fully integrated system approach to intelligent energy supply maximises renewable energy generation and the use of smart grids, including those outside the railway system, through links with the wider energy supply sector.



#6 Service timed to the second

Situational awareness, where each train's location and speed is known at all times and in real-time, supports service operation timed to the second. This results in increased and enhanced operational flexibility and contributes to a more robust, resilient, and reliable service as well as faster recovery from service disruption.

6A Automated vehicle identification and monitoring is the basis of precise service operation.

6B Smart traffic management ensures every train is in the right place and travelling at the right speed.

6C Automated dynamic timetables are facilitated. Automated recovery from perturbation (a "self-healing" process) quickly restores normal service.

#7 Low cost railway

Situational awareness, where each train's location and speed is known at all times and in real-time, supports service operation timed to the second. This results in increased and enhanced operational flexibility and contributes to a more robust, resilient, and reliable service as well as faster recovery from service disruption.

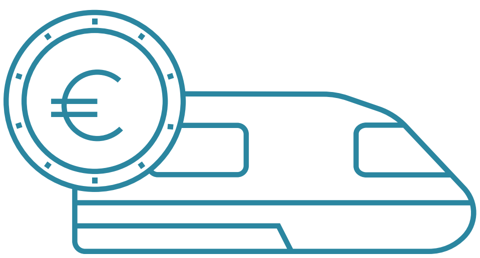
7A A low-cost, affordable rail system supports the rural economy. This is supported by the application of tailored standards.

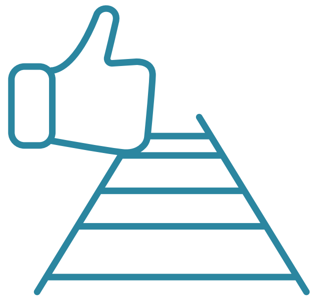
7B Simplified control-command system appropriate for low-intensity operation is used, allowing various degrees of autonomy.

7C The use of lightweight materials for rolling stock reduces maintenance costs and energy consumption.

7D A whole life operating cost approach balances the use of low-cost technical assets and good value service.

7E European simplified train certification processes and validation techniques reduce time and cost of product deliveries and subsequent modifications.





#8 Guaranteed asset health and availability

Optimised maintenance keeps the railway continuously open, fostering minimal disruption to train services. Shared real-time monitoring of asset health by a wide array of sensors connected together in an Internet of Things (IoT) environment feed the predictive maintenance decision-making process. Asset health and availability is further improved by machine-learning, artificial intelligence and big data analytics. Robust modular units and infrastructure are easily maintained and repaired through an automated system, making the operation punctual, safe, and quick.

8A The Internet of Things (IoT) enables real-time monitoring through connected sensors (ground/air/embedded).

8B Artificial Intelligence (AI) supports predictive maintenance decision-making to reduce manual interventions on infrastructure and rolling stock.

8C Greater use of robotics, modularity and automation simplifies maintenance and reduces the number of components.

8D Remote maintenance of trains and infrastructure allows operations to continue uninterrupted.

8E Performance based service specifications encourages a diverse supply chain.

#9 Intelligent trains

Intelligent trains are aware of themselves, their passengers/loads, and their surroundings, knowing where they need to be and when, and are able to automatically adjust journeys to meet demand. In addition, they intelligently feed information of infrastructure to support preventive maintenance. A network of fully intelligent trains can be self-regulating, negotiating vehicle to vehicle to resolve movement authorities and potential conflicts at junctions in the network and react to unexpected situations. The trains are also aware of and able to take account of the status of other transport modes.

9A Autonomous trains can monitor and regulate themselves.

9B Communications are possible between trains, between train and infrastructure and between train and passenger/freight customers.

9C Trains feature advanced mechatronics, reducing dependence on wheel conicity and permitting simplified running gear design.

9D In-train signalling capability is used to resolve conflicts at junctions and stations.

#10 Stations and “smart” city mobility

Rail is the backbone of urban mobility-with stations at the heart of ‘smart’ cities-being places to work, live, meet, and communicate, and where individual transport modes, including public transport and long-distance rail transport, are physically connected. New and modernised station designs provide easy access and seamless interchange between the transport modes, enabling railways to manage growing passenger volumes and mobility demands.

10A Railways are a core part of smart city mobility management systems and city fulfilment and delivery services. Stations are key to smart city governance structure and development plans.

10B Railways are connected to smart city mobility platforms for a seamless end-to-end journey within and beyond the city.

10C New designs of infrastructure and rail vehicles provide easy access and interchange between transport modes.

10D Flow management systems guide customers safely and efficiently through stations and to/from adjacent transport hub and city infrastructure, using dynamic wayfinding, barrier-free access, and multi-sensory information systems.

10E Platform management systems help passengers position themselves for their train and facilitate efficient boarding.

10F Security and revenue protection at stations and interchanges are based on electronic gates using smart wireless technologies, ticket detection systems and biometrics.

#11 Environmental and social sustainability

Railways continue to deliver sustainable transport solutions as overall travel demand intensifies. Rail makes an increased contribution to the transport economic mix, decoupling environmental harm from transport growth. Railways are able to operate with minimal environmental impact and with a low carbon footprint. Inclusive and easy access is available for all citizens to railway facilities, products, and services.

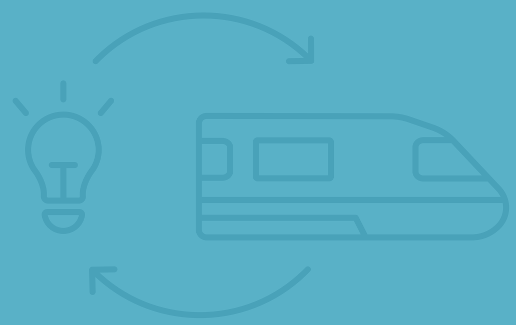
11A Adoption of ‘circular economy’ principles enables the railway to move towards ‘zero-waste’ operation, and a zero emission system in the long term.

11B Sustainable and ethical procurement and production reduces the carbon footprint, with a whole life approach and focus on inputs to the system, recycling, transport of materials, renewable energy, operations and disposals.

11C A climate change adaptive approach mitigates the impact of climate change on the railway.

11D Green technologies enable the railway to operate exhaust emissions-free and with low noise and vibration levels.

11E Information and accessible facilities put railways within the reach of citizens as an inclusive, affordable and accessible transport system.



#12 Rapid and reliable R&I delivery

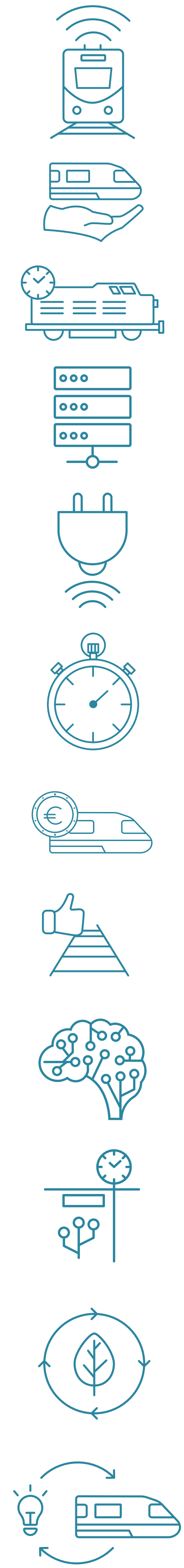
An ecosystem for R&I-based on effective collaboration, the provision of greater technology demonstration capability, and the rapid integration of technology into the railways, moves barriers to the adoption of new technologies and decreases time to market.

12A An R&I ecosystem with centres of excellence fosters a high participation in knowledge networks, opening new forms of collaboration, technology transfer from other industry sectors, and keeping railway skill sets fresh.

12B The sector has a strong commercial focus and awareness of the maturity levels of new technologies. There is a well-coordinated and fast decision-making process, reducing time to market.

12C Virtual testing and efficient implementation processes speed up production and deployment of new products. There is close cooperation within the sector for standardisation and testing. Component-driven development and modularised products are key elements of a rapid deployment of innovation to the market. Railways have a permanent focus on “disruptive technologies,” using their challenges to increase their innovation capabilities and speed.

12D Agile development approaches, living labs, hackathons, and early involvement of customers are the elements of customer-centric innovations. Open-labs invite end-users/customers to be part of the innovation process.



5

S2R ROADMAP TO DELIVER THE INNOVATION CAPABILITIES

Developing these capabilities requires a coordinated effort to drive innovation at all levels. S2R is designed to make a decisive contribution to delivering the essential knowledge that will provide the building blocks of such capabilities.

As indicated in the S2R MP, the work conducted within the S2R Programme is structured around five asset-specific Innovation Programmes (IPs), covering all the different structural (technical) and functional (process) sub-systems of the rail system. These five IPs are supported by work in five cross-cutting areas (CCA), covering themes that are of relevance to each of the projects and which address the interactions between the IPs and the different subsystems. This overall programme structure is shown in Fig. 6.

S2R addresses the IPs and CCA by funding R&I activities that range from fundamental research (technology readiness level, TRL 0 to 3), through applied research (TRL 3 to 5) to demonstration activities (TRL 5 to 7), i.e. from exploring ideas, through technology and operational developments demonstrated at laboratory level, to system prototype demonstrations in operational environments. Specifically, the following existing and established market segments are being considered:

- high-speed passenger rail;
- regional passenger rail;
- urban/suburban passenger rail;
- rail freight.

S2R Members are also required to conduct 'additional activities' to leverage the effect of the R&I activities undertaken. These additional activities are not eligible for financial support from S2R and are not included in this MAAP, but contribute directly to the broader objectives set out in the S2R MP.

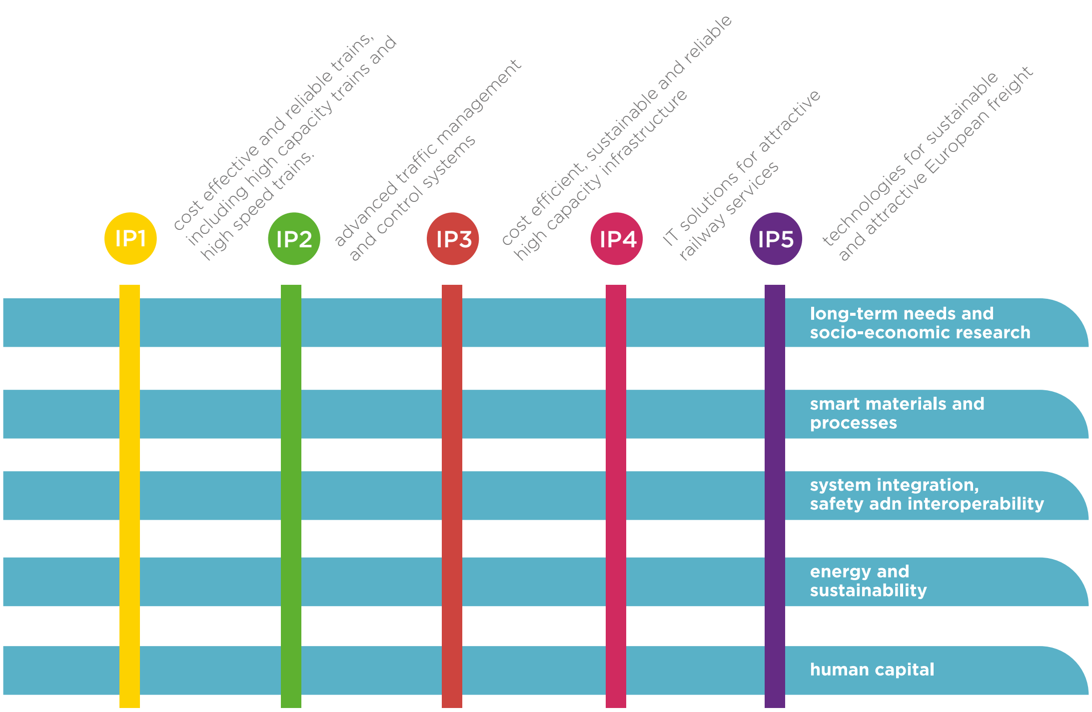


Fig. 6. Shift2Rail overall structure

5.1. THE S2R R&I STRUCTURE

Demonstration activities are a priority within Shift2Rail, as they enable the rail sector to:

- visualise and test the transformations that that are being created;
- quantify the impact of each new technology, either alone or in combination
- with other innovations;
- provide a first estimate of the potential for improvement in the sector at
- multiple levels of the transport network (regional, national, and EU);
- enhance the perceived innovation potential of the sector ; and
- revitalise the industry by attracting the next generation of top graduates from universities across Europe.

The demonstration of technical achievements, up to TRL 7, is being based on the three-fold architecture presented in Fig. 7 below, namely technology demonstrators (TDs), integrated technology demonstrators (ITDs), and system platform demonstrators (SPDs).

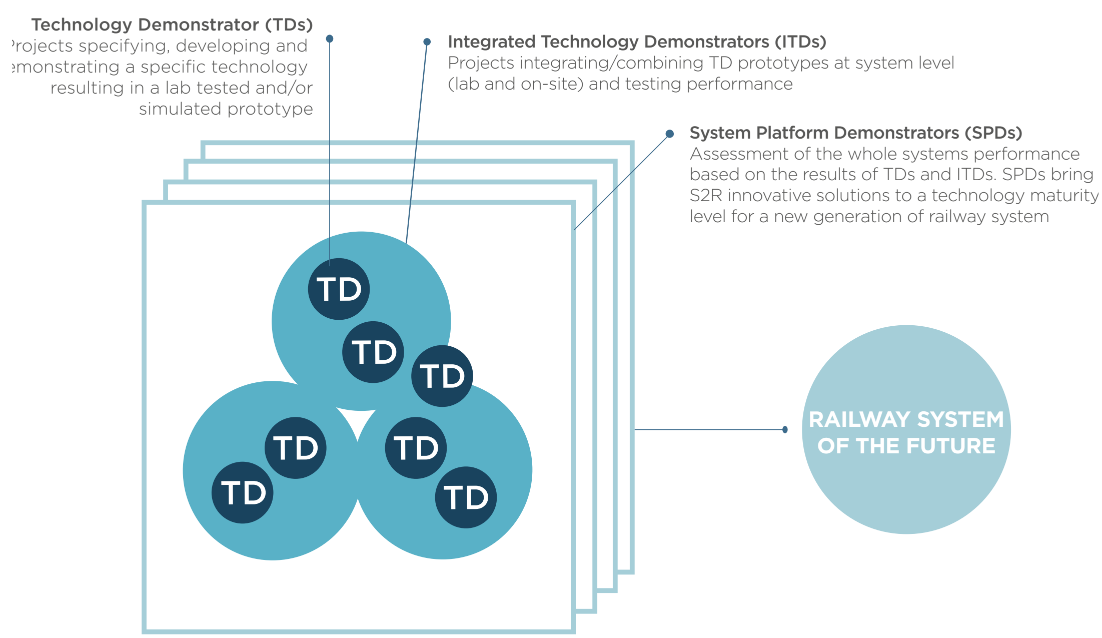


Fig. 7. Structure of Shift2Rail demonstrators

Technology Demonstrators (TDs)

Technology Demonstrators focus on the development or adoption of innovative technologies and models within the rail sub-systems identified in the Innovation Programmes. They are designed to enable ground-breaking progress in key areas such as traction, automatic train operation, and intelligent diagnosis and maintenance systems, all linked to the capabilities discussed in Section 2 of this document. The innovations developed may consist of software and/or hardware systems.

Before being combined into Integrated Technology Demonstrators (ITDs), each TD is being tested in one or more prototypes to assess the individual performance of the technologies developed, and, where possible, demonstrate the conformity with technical requirements that apply to the product developed. These tests can be performed in labs and test tracks or on existing trains, and are differentiated if different business segments are addressed.

Integrated Technology Demonstrators (ITDs)

The ITDs allow for the testing of combinations of components and sub-systems already verified and validated within the Technology Demonstrators: they will constitute part of the Innovation Capabilities. Their aim is to demonstrate the innovation potential of the components in different sub-systems and systems, considering functional and operational specifications and the technical interfaces among the various TDs.

ITDs also enable the analysis of compliance with the regulatory requirements. The validation of technologies will be followed up with a controlled approach to future authorisation and certification work. All of which forms part of the necessary steps towards ensuring the capabilities identified can be deployed.

System Platform Demonstrations (SPDs)

Ultimately, S2R will carry out proof and analysis of rail systems, design, and functions on fully representative innovative railway configurations in an integrated environment, simulating real operational conditions.

SPDs are conceived to simulate and virtually test the interaction and impact of the various innovative systems resulting from the Shift2Rail activities in the specific environments of each of the relevant market segments.

These SPDs are shaped by the evolving impact assessment of key transversal issues critical for the sector, including the societal trends discussed in Section 2 of this report (e.g., ageing population, digitalisation).

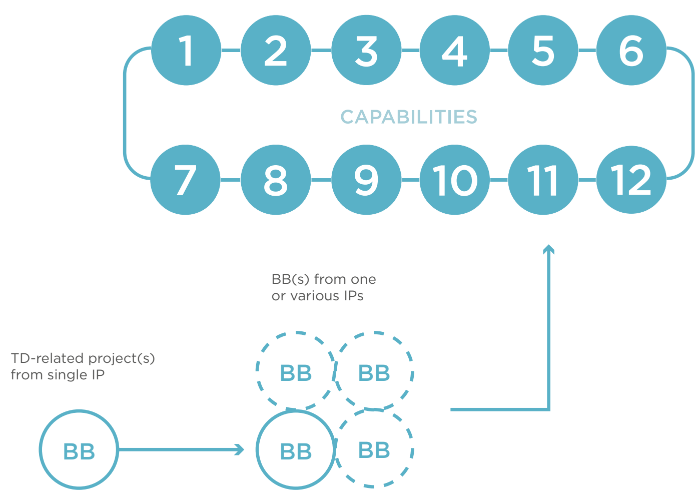
The design of demonstration platforms considers the characteristics of each market segment, its challenges and needs, as well as the promising market opportunities. Based on this initial assessment, the SPDs will demonstrate how the correct aggregation of different innovations can greatly contribute to improve the performance of the sector. This will be based on an analysis of detailed Key Performance Indicators (KPIs) on simulated models and measured against the S2R objectives as defined in the Master Plan. In this respect, it is possible that the deliverables of the same TD are relevant for more than one of the different railway transportation segments. Results of one TD may therefore be demonstrated in more than one SPD if it is considered that these results correspond to the business needs of several rail market segments.

The exact definition of each SPD is part of the work to be done in the S2R System Integration working group of the JU considering the input from the broad stakeholder community (as well as relevant results of the S2R projects - lighthouse, open calls and member-only projects).

5.2. HOW S2R WILL ACHIEVE ITS VISION

The five asset-specific Innovation Programmes (IPs) and five cross-cutting work areas (CCA) as seen in Fig. 6 form the basis of the S2R R&I Programme and are described in detail in the S2R MP (Section 3, pp. 23-53).

Their contribution to achieving the necessary capabilities that will realise the vision is being assessed though the completion of building blocks (BB). A building block is understood as a complete and distinct enabler of one or more capabilities which is formed by TDs outcome(s).



IP1_Cost-efficient and reliable trains, including high capacity trains and high speed trains

The following diagram (Fig. 9) summarises the building blocks associated with the various TDs planned in IP1 and their related deliverables.

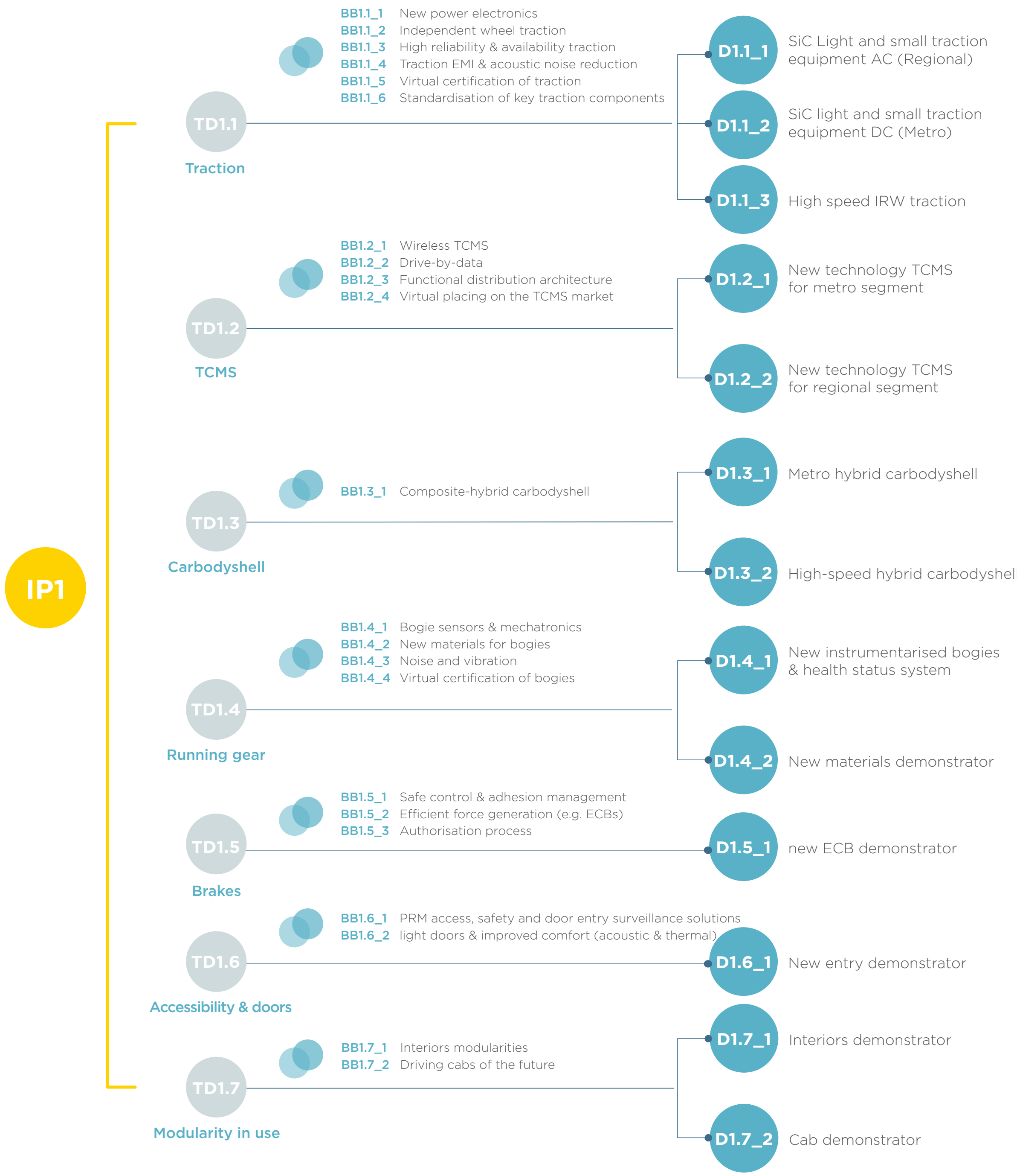


Fig. 9. IP1 Building blocks (BBs) and deliverables associated with its Technology demonstrators (TDs)

Similarly, IP1 technological building blocks can be mapped out to the capabilities they contribute to as follows:

IP1	TD1.1 Traction	TD1.2 TCMS	TD1.3 Carbodyshell	TD1.4 Running gear	TD1.5 Brakes	TD1.6 Accessibility & doors	TD1.7 Modularity in use
Automated train operation 1		BB1.2_1 BB1.2_2		BB1.4_1	BB1.5_1 BB1.5_2	BB1.6_1	BB1.7_2
Mobility as a Service 2		BB1.2_1		BB1.4_1		BB1.6_1 BB1.6_2	BB1.7_1
Logisitcs on demand 3							
More value from data 4	BB1.1_3	BB1.2_1 BB1.2_2 BB1.2_3		BB1.4_1		BB1.6_1	
Optimum energy use 5	BB1.1_1 BB1.1_2	BB1.2_1	BB1.3_1	BB1.4_2		BB1.6_2	
Service operation timed to the second 6		BB1.2_1			BB1.5_1 BB1.5_2	BB1.6_1	BB1.7_1
Low cost railway 7	BB1.1_1 BB1.1_2 BB1.1_3 BB1.1_5 BB1.1_6	BB1.2_2 BB1.2_3 BB1.2_4	BB1.3_1 BB1.3_4	BB1.4_1 BB1.4_4	BB1.5_3	BB1.6_1 BB1.6_2	BB1.7_1
Guaranteed asset health and availability 8	BB1.1_3	BB1.2_1		BB1.4_1			
Intelligent trains 9	BB1.1_3	BB1.2_1		BB1.4_1	BB1.5_1 BB1.5_2	BB1.6_1	
Stations and "smart" city mobility 10		BB1.2_1				BB1.6_1	BB1.7_1
Environmental and social sustainability 11	BB1.1_4			BB1.4_3			
Rapid and reliable R&D delivery 12							

Fig. 10. IP1 alignment of building blocks (BBs) with capabilities

IP2_Advanced traffic management and control systems

The following diagram (Fig. 11) summarises the building blocks associated with the various TDs planned in IP2 and their related deliverables. These are considered to be the building blocks with the most relevant contribution towards the achievement of the given capability. Additional IP2 TDs might have an influence on a capability but are deemed more general. For instance, adaptable communications (TD2.1) and cyber security (TD2.11) are linked to the need of communications for all systems and as such contribute in some degree to all capabilities.

Fig. 11. IP2 Building blocks (BBs) and deliverables associated with its Technology demonstrators (TDs)

These IP2 technological building blocks can be mapped out to the capabilities they contribute to as follows:

IP2		TD2.1 Adaptable comms	TD2.1 ATO	TD2.1 Moving block	TD2.1 train positioning	TD2.1 Train integrity	TD2.1 on-site testing	TD2.1 Formal methods	TD2.1 virtual coupling	TD2.1 Traffic management	TD2.1 train-wayside comms	TD2.1 Cyber security
Automated train operation	1	BB2.1_1 BB2.1_2 BB2.1_3	BB2.2_1 BB2.2_2	BB2.3_1 BB2.3_2	BB2.4_1 BB2.4_2 BB2.4_3	BB2.5_1 BB2.5_2			BB2.8_1 BB2.8_2 BB2.8_3	BB2.9_1 BB2.9_2 BB2.9_3	BB210_1 BB210_2 BB210_3 BB210_4	BB211_1 BB211_2
Mobility as a Service	2									BB2.9_1 BB2.9_2 BB2.9_3		
Logisitcs on demand	3		BB2.2_1 BB2.2_2						BB2.8_1 BB2.8_2 BB2.8_3	BB2.9_1 BB2.9_2 BB2.9_3		
More value from data	4	BB2.1_1 BB2.1_2 BB2.1_3								BB2.9_1 BB2.9_2 BB2.9_3		BB211_1
Optimum energy use	5		BB2.2_1 BB2.2_2							BB2.9_1 BB2.9_2 BB2.9_3		
Service operation timed to the second	6	BB2.1_1 BB2.1_2 BB2.1_3	BB2.2_1 BB2.2_2	BB2.3_1 BB2.3_2	BB2.4_1 BB2.4_2 BB2.4_3	BB2.5_1 BB2.5_2			BB2.8_1 BB2.8_2 BB2.8_3	BB2.9_1 BB2.9_2 BB2.9_3	BB210_1 BB210_2 BB210_3 BB210_4	BB211_1 BB211_2
Low cost railway	7	BB2.1_1 BB2.1_2 BB2.1_3	BB2.2_1 BB2.2_2	BB2.3_1 BB2.3_2	BB2.4_1 BB2.4_2 BB2.4_3	BB2.5_1 BB2.5_2	BB2.6_1 BB2.6_2 BB2.6_3	BB2.7_1 BB2.7_2	BB2.8_1 BB2.8_2 BB2.8_3	BB2.9_1 BB2.9_2 BB2.9_3	BB210_1 BB210_2 BB210_3 BB210_4	BB211_1 BB211_2
Guaranteed asset health and availability	8	BB2.1_1 BB2.1_2 BB2.1_3								BB2.9_1 BB2.9_2 BB2.9_3	BB210_1 BB210_2 BB210_3 BB210_4	BB211_1 BB211_2 BB211_3
Intelligent trains	9	BB2.1_1 BB2.1_2 BB2.1_3	BB2.2_1 BB2.2_2	BB2.3_1 BB2.3_2	BB2.4_1 BB2.4_2 BB2.4_3	BB2.5_1 BB2.5_2			BB2.8_1 BB2.8_2 BB2.8_3	BB2.9_1 BB2.9_2 BB2.9_3	BB210_1 BB210_2 BB210_3 BB210_4	BB211_1 BB211_2
Stations and “smart” city mobility	10	BB2.1_1 BB2.1_2 BB2.1_3										BB211_1 BB211_2 BB211_3
Environmental and social sustainability	11											
Rapid and reliable R&D delivery	12						BB2.6_1 BB2.6_2 BB2.6_3	BB2.7_1 BB2.7_2				

Fig. 12. IP2 alignment of building blocks (BBs) with capabilities

As an example, this matrix shows that achieving Capability 1 (Automated Train Operation) requires contribution from most of IP2 TDs:

- TD2.2 - ATO evolution towards a high grade of automation facilitates the basis for further enhancements (e.g., automated train preparation, self-controlled trains);
- TD2.3 - Moving Block is a fundamental operational characteristic for any future improvement of line capacity and the achievement of flexible services based on trains running closer together;
- TD2.4 – Fail-safe train positioning, which includes also Global Navigation Satellite System (GNSS) technologies, is a key intermediate technology for any evolution towards new train operational concepts;
- TD2.5 - On-board Train Integrity is essential for implementing any operational systems based on train self-localisation while reducing the need of trackside train detection systems (e.g., track circuits or axle counters);
- TD2.8 - Virtual Coupling aims to check the real feasibility of having trains running closer within their absolute braking distance. It is categorically the key Technical Demonstrator that can enable a move towards a new paradigm in railway systems;
- Automation implies improvements to communications (TD2.1) and security (TD2.11);
- TD2.10 paves the way to introducing train-to-wayside direct communications as a facilitator of a future train-centric system;
- TD2.9 - The contribution of the Traffic Management is deemed essential for further improvements in terms of new functions due to the application of the new operational concepts.

IP3_Cost-efficient, sustainable and reliable high capacity infrastructure

As with previous IPs, the following diagram (Fig. 13) summarises the building blocks associated with the various TDs planned in IP3 and their related deliverables.

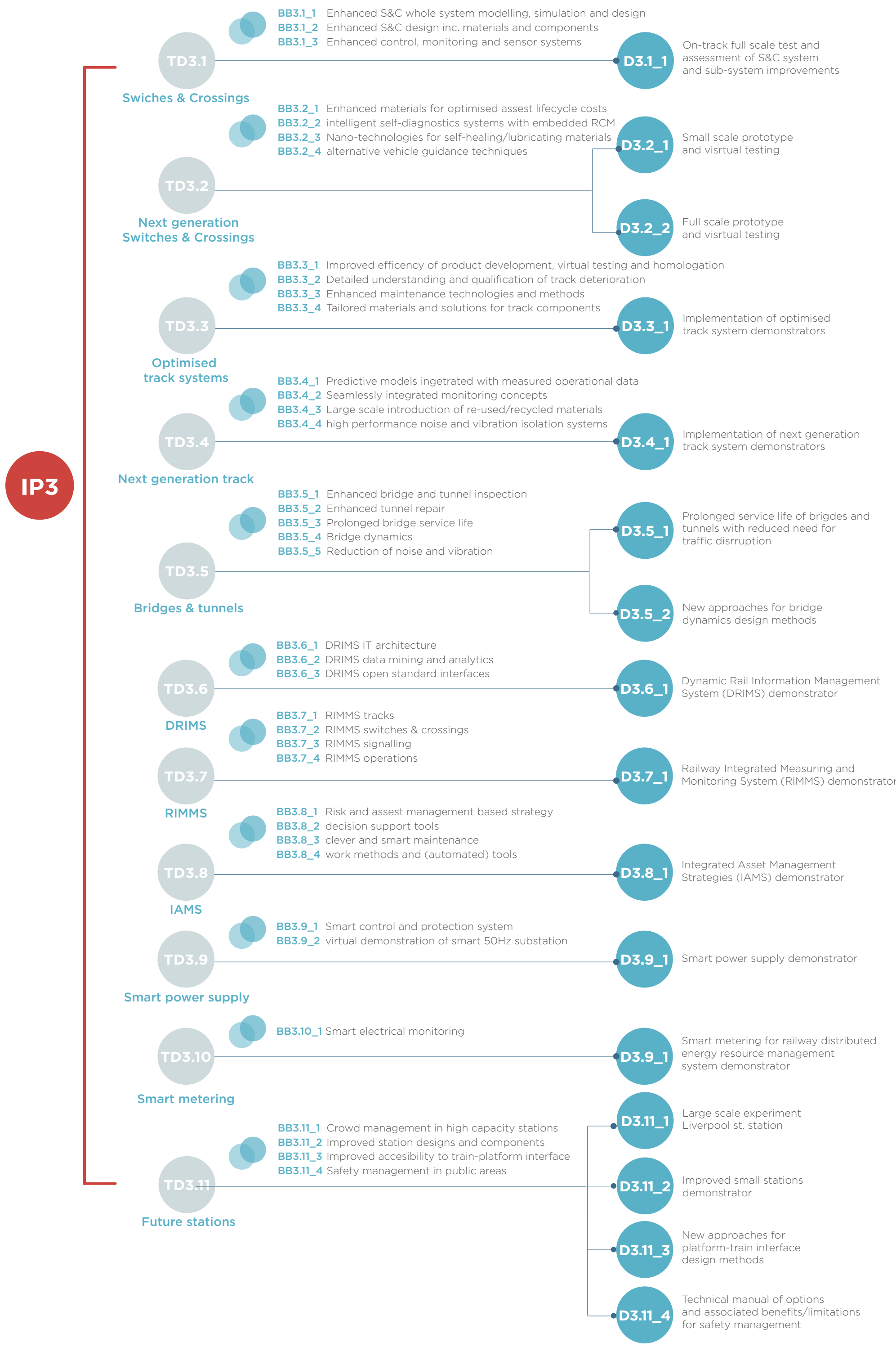


Fig. 13. IP3 Building blocks (BBs) and deliverables associated with its Technology demonstrators (TDs)

These IP3 technological building blocks can be mapped out to the capabilities they contribute to as follows:

IP3	TD3.1 S&C	TD3.2 Next gen S&C	TD3.3 Optimised track systems	TD3.4 Next generation track systems	TD3.5 Bridges & tunnels	TD3.6 DRIMS	TD3.7 RIMMS	TD3.8 IAMS	TD3.9 Smart power supply	TD3.10 Smart metering	TD3.11 Future stations
Automated train operation 1		BB3.2_5		BB3.4_3			BB3.7_4	BB3.8_2 BB3.8_3 BB3.8_4			
Mobility as a Service 2				BB3.4_1							BB311_1 BB311_2 BB311_3 BB311_4
Logisitcs on demand 3				BB3.4_3				BB3.8_2 BB3.8_3			
More value from data 4	BB3.1_1	BB3.2_3	BB3.3_2	BB3.4_1	BB3.5_1	BB3.6_2	BB3.7_1 BB3.7_2 BB3.7_3 BB3.7_4	BB3.8_2 BB3.8_3 BB3.8_4	BB3.9_1	BB210_6	BB311_1 BB311_4
Optimum energy use 5		BB3.2_1 BB3.2_4		BB3.4_2					BB3.9_1 BB3.9_2	BB210_6	BB311_2
Service operation timed to the second 6		BB3.2_3 BB3.2_5		BB3.4_1				BB3.8_1 BB3.8_2 BB3.8_3 BB3.8_4			
Low cost railway 7	BB3.1_1	BB3.1_1 BB3.1_3 BB3.1_4	BB3.3_1 BB3.3_2 BB3.3_3 BB3.3_4		BB3.5_1 BB3.5_2 BB3.5_3 BB3.5_4	BB3.6_1 BB3.6_2	BB3.7_1 BB3.7_2 BB3.7_3 BB3.7_4	BB3.8_1 BB3.8_2 BB3.8_3 BB3.8_4	BB3.9_1 BB3.9_2		BB311_2 BB311_3
Guaranteed asset health and availability 8	BB3.1_1 BB3.1_2 BB3.1_3	BB3.2_3 BB3.2_4	BB3.3_2 BB3.3_3 BB3.3_4	BB3.4_2	BB3.5_1 BB3.5_2 BB3.5_3	BB3.6_2	BB3.7_1 BB3.7_2 BB3.7_3	BB3.8_2 BB3.8_3 BB3.8_4			
Intelligent trains 9		BB3.2_5	BB3.3_2	BB3.4_3 BB3.4_4	BB3.5_1					BB210_6	
Stations and "smart" city mobility 10	BB3.1_1 BB3.1_2 BB3.1_3	BB3.1_1 BB3.1_3 BB3.1_4	BB3.3_1 BB3.3_2 BB3.3_3 BB3.3_4		BB3.5_1 BB3.5_2 BB3.5_3 BB3.5_4	BB3.6_1 BB3.6_2 BB3.6_3	BB3.7_1 BB3.7_2 BB3.7_3 BB3.7_4	BB3.8_1 BB3.8_2 BB3.8_3 BB3.8_4	BB3.9_1 BB3.9_2	BB210_6	BB311_2 BB311_3
Environmental and social sustainability 11	BB3.1_2 BB3.1_3	BB3.2_1 BB3.2_4	BB3.3_2 BB3.3_3 BB3.3_4		BB3.5_3 BB3.5_4 BB3.5_5			BB3.8_2	BB3.9_1	BB210_6	BB311_2
Rapid and reliable R&D delivery 12	BB3.1_1		BB3.3_2 BB3.3_3 BB3.3_4		BB3.5_1 BB3.5_2 BB3.5_3 BB3.5_4	BB3.6_1 BB3.6_2	BB3.7_1 BB3.7_2	BB3.8_2 BB3.8_3	BB3.9_1 BB3.9_2	BB210_6	

Fig. 14. IP3 alignment of building blocks (BBs) with capabilities

IP4_IT Solutions for attractive railway services

The building blocks associated with the various TDs planned in IP4 and their related deliverables are summarised in Fig. 15.

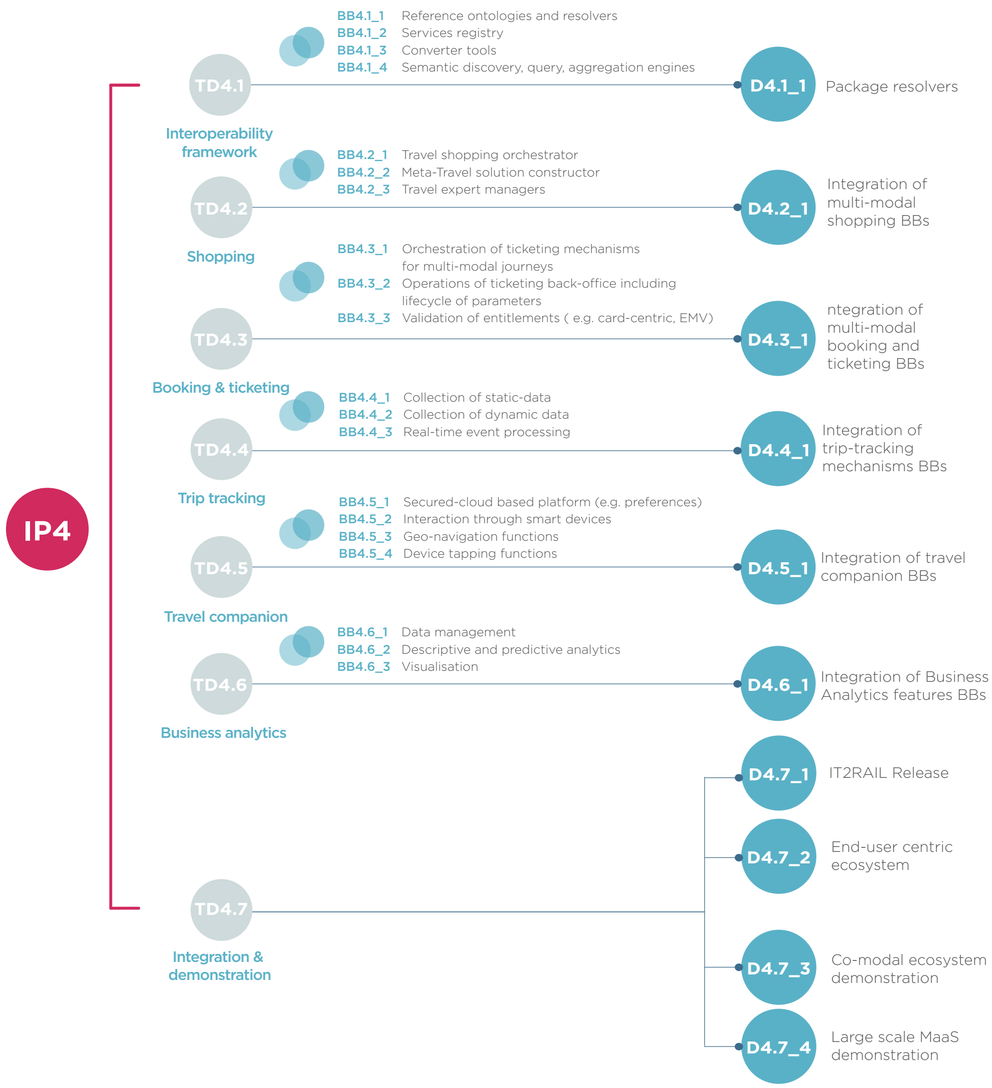


Fig. 15. IP4 Building blocks (BBs) and deliverables associated with its Technology demonstrators (TDs)

These IP4 technological building blocks can be mapped out to the capabilities they contribute to as follows:

IP4		TD4.1 Interoperability framework	TD4.2 Shopping	TD4.3 Booking & ticketing	TD4.4 Trip tracking	TD4.5 Travel companion	TD4.6 Business analytics	TD4.7 Integration & demonstration
Automated train operation	1							
Mobility as a Service	2	BB4.1_1 BB4.1_2 BB4.1_3 BB4.1_4	BB4.2_1 BB4.2_2 BB4.2_3	BB4.3_1 BB4.3_2 BB4.3_3	BB4.4_1 BB4.4_2 BB4.4_3	BB4.5_1 BB4.5_2 BB4.5_3 BB4.5_4		integrates all BBs for Capbility 2
Logisitcs on demand	3							
More value from data	4	BB4.1_1 BB4.1_2 BB4.1_3 BB4.1_4			BB4.4_1 BB4.4_2 BB4.4_3	BB4.5_1 BB4.5_2 BB4.5_3 BB4.5_4	BB4.6_1 BB4.6_2 BB4.6_3	integrates all BBs for Capbility 4
Optimum energy use	5							
Service operation timed to the second	6							
Low cost railway	7							
Guaranteed asset health and availability	8							

Fig. 16. IP4 alignment of building blocks (BBs) with capabilities

IP5_ Technologies for sustainable and attractive European rail freight

The building blocks associated with the seven TDs planned in IP5 and their related deliverables are summarised in Fig. 17.

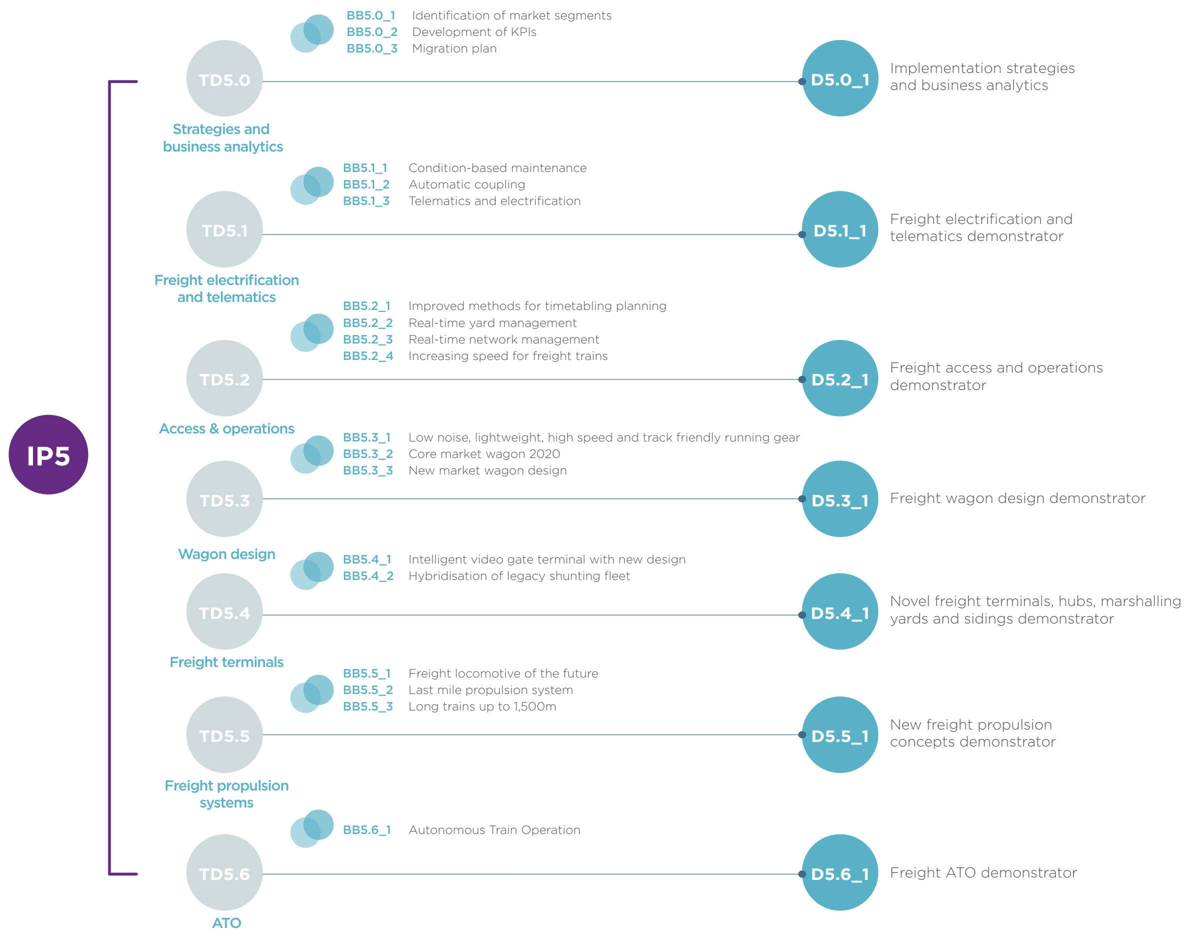


Fig. 17. IP5 Building blocks (BBs) and deliverables associated with its Technology demonstrators (TDs)

IP5 technological building blocks can be mapped out to the capabilities they contribute to as follows:

IP5	TD5.0 Strategies & business analytics	TD5.1 Freight electrification & telematics	TD5.2 Access & operations	TD5.3 Wagon design	Freight terminals	TD5.5 Freight propulsion systems	TD5.6 ATO
1 Automated train operation		BB5.1_2	BB5.2_1		BB5.4_1		BB5.6_1
2 Mobility as a Service							
3 Logisitcs on demand	BB5.0_1	BB5.1_2 BB5.1_3	BB5.2_1 BB5.2_2 BB5.2_3 BB5.2_4	BB5.3_1 BB5.3_2 BB5.3_3	BB5.4_1 BB5.4_2	BB5.5_1 BB5.5_2 BB5.5_3	BB5.6_1
4 More value from data	BB5.0_1	BB5.1_1 BB5.1_3	BB5.2_2 BB5.2_3	BB5.3_2 BB5.3_3	BB5.4_1		BB5.6_1
5 Optimum energy use		BB5.1_2	BB5.2_1 BB5.2_3		BB5.4_2	BB5.5_1 BB5.5_2	BB5.6_1
6 Service operation timed to the second		BB5.1_1 BB5.1_2 BB5.1_3	BB5.2_1	BB5.3_2 BB5.3_3			BB5.6_1
7 Low cost railway	BB5.0_1				BB5.4_2	BB5.5_2	BB5.6_1
8 Guaranteed asset health and availability		BB5.1_1					BB5.6_1
9 Intelligent trains		BB5.1_3		BB5.3_2 BB5.3_3		BB5.5_1 BB5.5_3	BB5.6_1
10 Stations and "smart" city mobility		BB5.1_2	BB5.2_2 BB5.2_3		BB5.4_1		BB5.6_1

Fig. 18. IP5 alignment of building blocks (BBs) with capabilities

CCA_ Cross Cutting Activities

The building blocks associated with the eleven work activities (WA) planned in CCA and their related deliverables are summarised in Fig. 19.

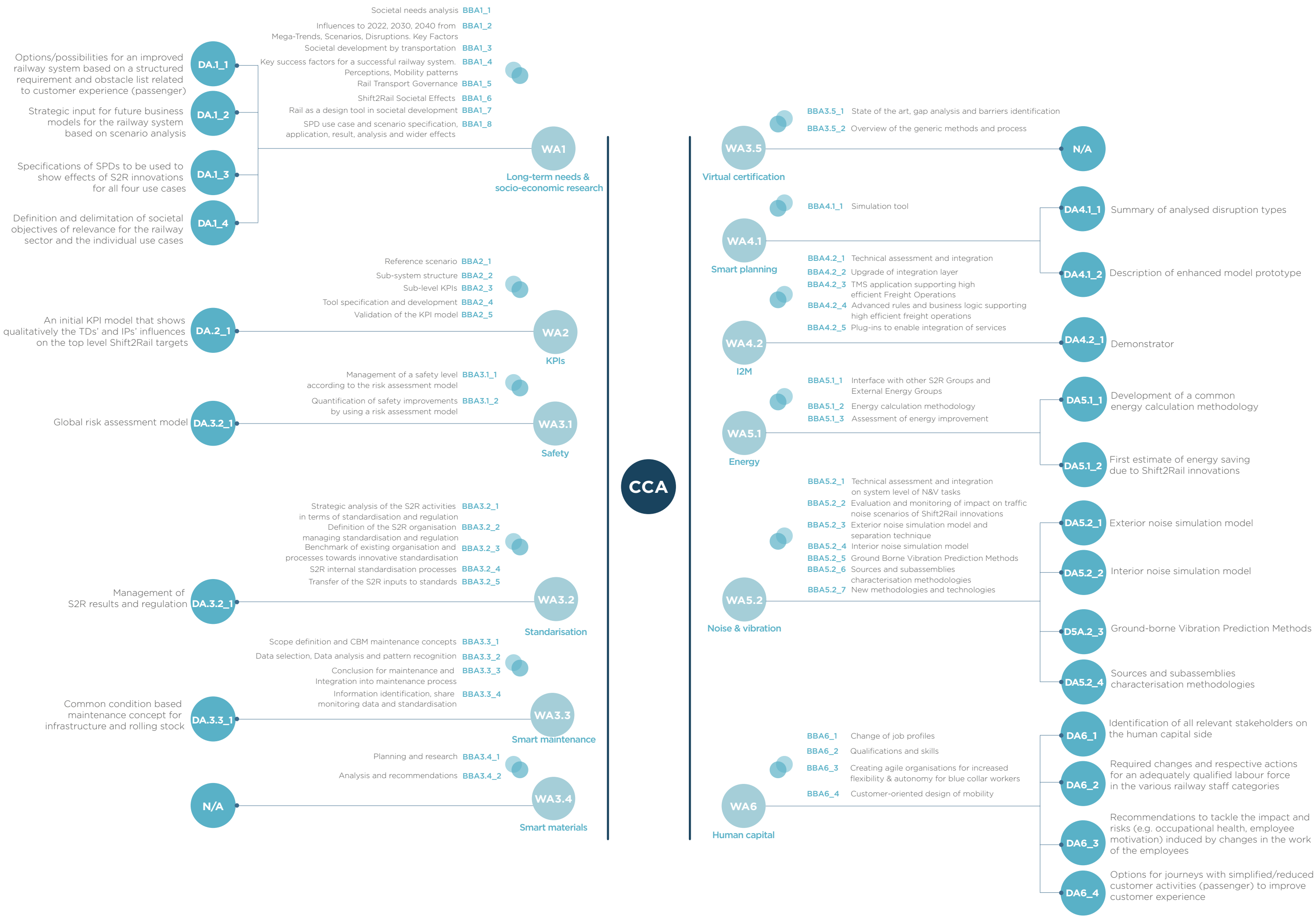


Fig. 19. IP4 Building blocks (BBs) and deliverables associated

These CCA building blocks can be mapped out to the capabilities they contribute to as follows:

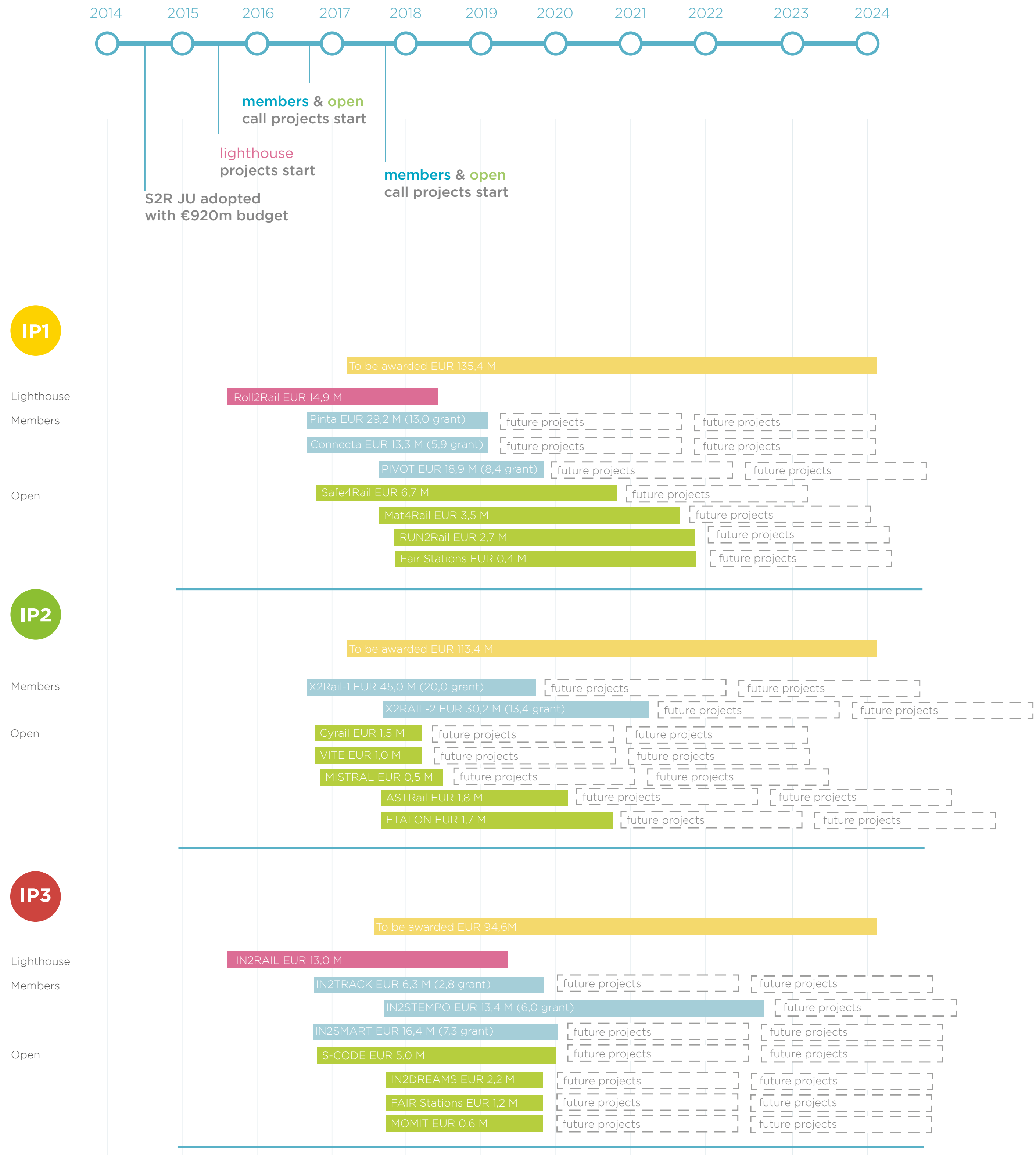
CCA	WA1 Socio-ecn. & research	WA2 KPIs	WA3.1 Safety	WA3.2 Standarisation	WA3.3 Smart maintenance	WA3.4 Smart materials	WA3.5 Virtual certification	WA4.1 Smart planning	WA4.2 I2M	WA5.1 Energy	WA5.2 Noise & vibration	WA6 Human capital
1 Automated train operation			BBA3.1_1 BBA3.1_2	BBA3.2_	BBA3.3_6	BBA3.4_2	BBA3.5_2	BBA4.1_1	BBA4.2_	BBA5.1_		
2 Mobility as a Service									BBA4.2_			
3 Logisitcs on demand				BBA3.2_				BBA4.1_1	BBA4.2_			
4 More value from data				BBA3.2_	BBA3.3_6		BBA3.5_2		BBA4.2_	BBA5.1_		
5 Optimum energy use				BBA3.2_		BBA3.4_2	BBA3.5_2		BBA4.2_	BBA5.1_		
6 Service operation timed to the second	All eight BBs cover all twelve capabilities	All five BBs cover all twelve capabilities		BBA3.2_				BBA4.1_1	BBA4.2_	BBA5.1_	BBA5.2_	All four BBs cover all twelve capabilities
7 Low cost railway				BBA3.2_		BBA3.4_2	BBA3.5_2		BBA4.2_	BBA5.1_		
8 Guaranteed asset health and availability			BBA3.1_2		BBA3.3_6				BBA4.2_			
9 Intelligent trains				BBA3.2_	BBA3.3_6	BBA3.4_2	BBA3.5_2		BBA4.2_	BBA5.1_		
10 Stations and "smart" city mobility						BBA3.4_2	BBA3.5_2	BBA4.1_1	BBA4.2_			
11 Environmental and social sustainability									BBA4.2_	BBA5.1_	BBA5.2_	
12 Rapid and reliable R&D delivery					BBA3.3_6	BBA3.4_2	BBA3.5_2		BBA4.2_	BBA5.1_	BBA5.2_	

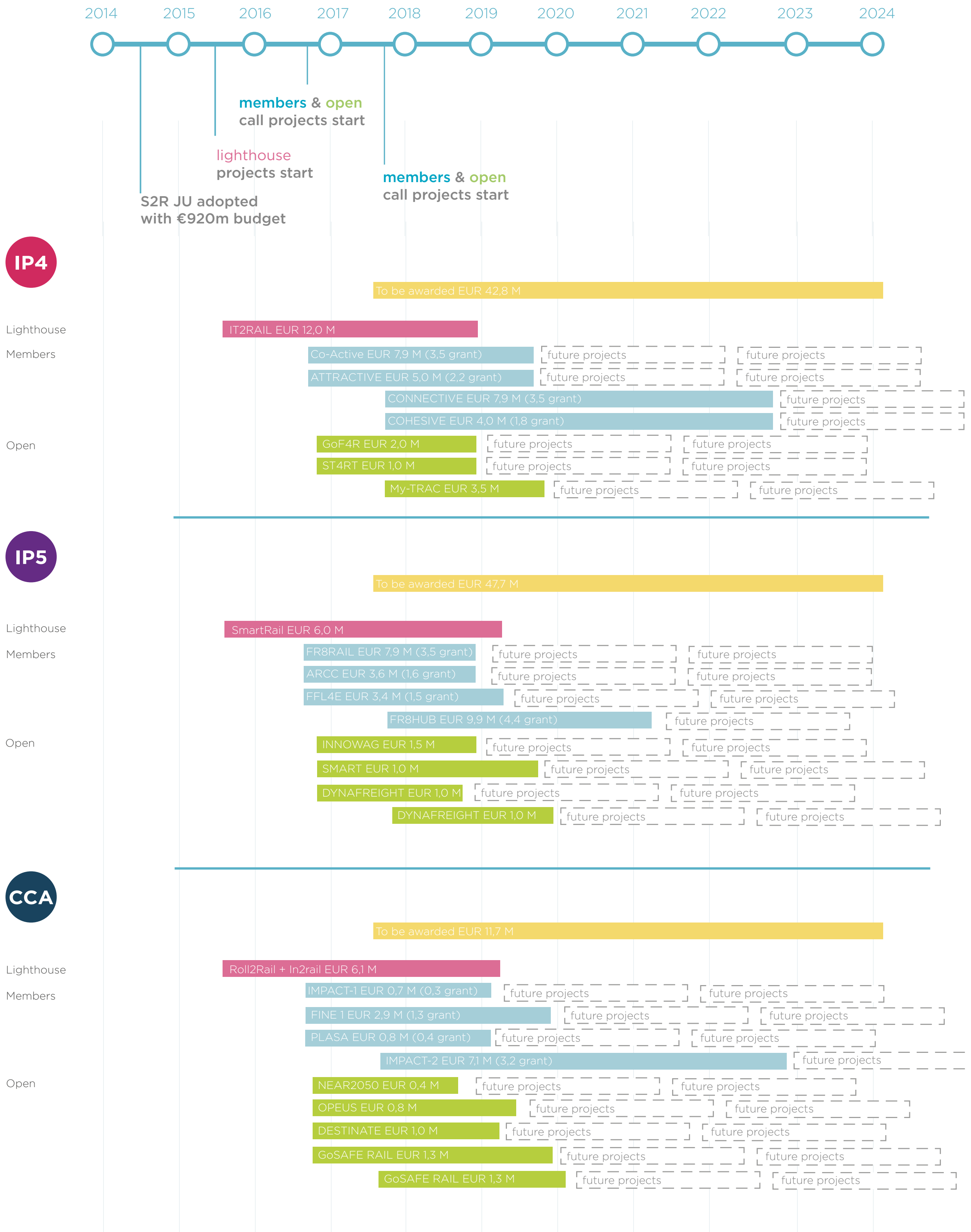
Fig. 20 CCA alignment of building blocks (BBs) with capabilities

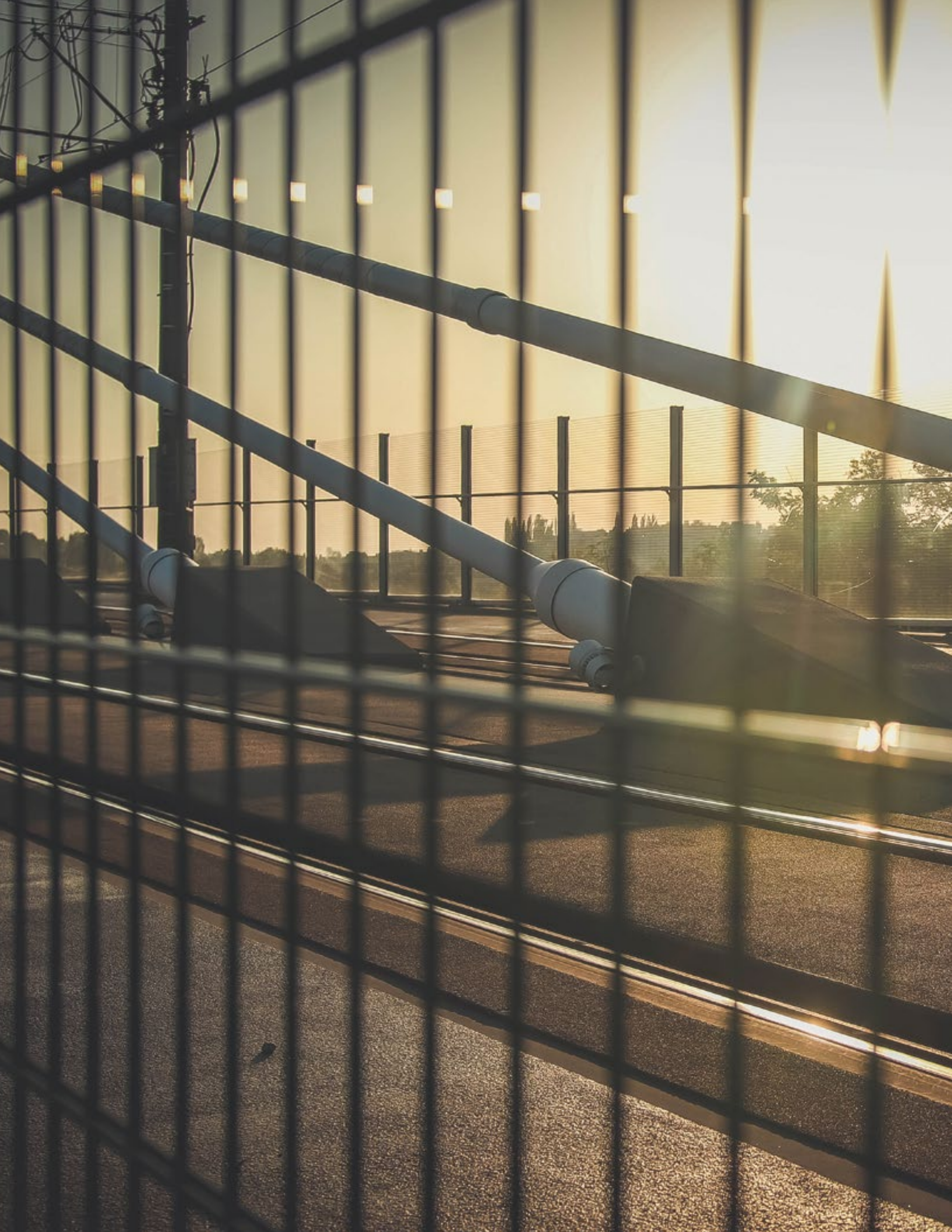
5.3. PROGRAMME TIMELINES

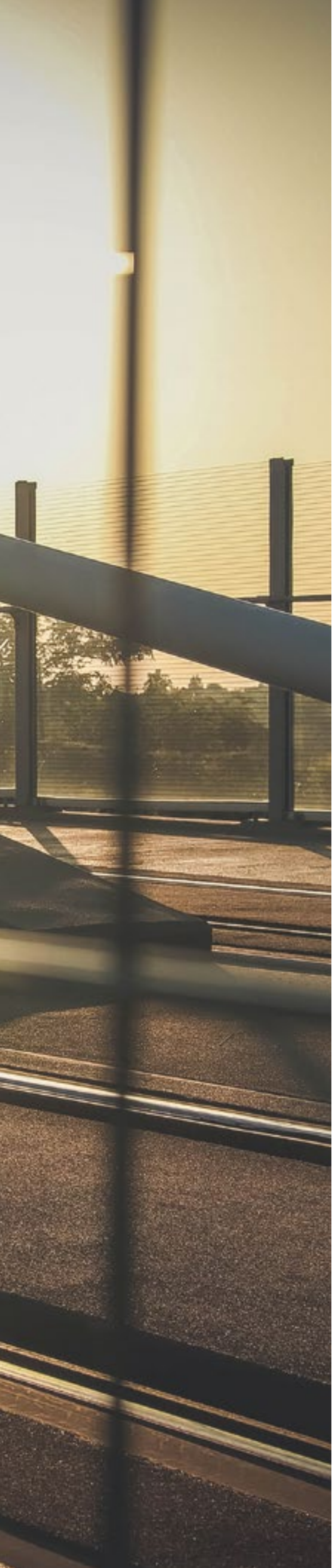
Since the 2014 adoption of Council Regulation No 642/2014 establishing the Shift2Rail JU and the subsequent introduction of the first edition of the Multi-Annual Action Plan (MAAP) in November 2015, R&I activities for around EUR 400 million have already been invested through the H2020 Lighthouse projects and specific ongoing S2R projects. The following diagram (Fig. 21) summarises the status of the R&I program while general details of these ongoing projects can be found in Appendix A and online[17].

17 http://shift2rail.org/projects/


2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
members & open call projects start
lighthouse projects start
S2R JU adopted with €920m budget
members & open call projects start
IP1
To be awarded EUR 135,4 M
Lighthouse
Roll2Rail EUR 14,9 M
Members
Pinta EUR 29,2 M (13,0 grant)
future projects
future projects
Connecta EUR 13,3 M (5,9 grant)
future projects
future projects
PIVOT EUR 18,9 M (8,4 grant)
future projects
future projects
Open
Safe4Rail EUR 6,7 M
future projects
Mat4Rail EUR 3,5 M
future projects
RUN2Rail EUR 2,7 M
future projects
Fair Stations EUR 0,4 M
future projects
IP2
To be awarded EUR 113,4 M
Members
X2Rail-1 EUR 45,0 M (20,0 grant)
future projects
future projects
X2RAIL-2 EUR 30,2 M (13,4 grant)
future projects
future projects
Open
Cyrail EUR 1,5 M
future projects
future projects
VITE EUR 1,0 M
future projects
future projects
MISTRAL EUR 0,5 M
future projects
future projects
ASTRail EUR 1,8 M
future projects
future projects
ETALON EUR 1,7 M
future projects
future projects
IP3
To be awarded EUR 94,6M
Lighthouse
IN2RAIL EUR 13,0 M
Members
IN2TRACK EUR 6,3 M (2,8 grant)
future projects
future projects
IN2STEMPO EUR 13,4 M (6,0 grant)
future projects
IN2SMART EUR 16,4 M (7,3 grant)
future projects
future projects
Open
S-CODE EUR 5,0 M
future projects
future projects
IN2DREAMS EUR 2,2 M
future projects
future projects
FAIR Stations EUR 1,2 M
future projects
future projects
MOMIT EUR 0,6 M
future projects
future projects


2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
members & open call projects start
lighthouse projects start
S2R JU adopted with €920m budget
members & open call projects start
IP4
To be awarded EUR 42,8 M
Lighthouse
IT2RAIL EUR 12,0 M
Members
Co-Active EUR 7,9 M (3,5 grant)
ATTRACTIVE EUR 5,0 M (2,2 grant)
CONNECTIVE EUR 7,9 M (3,5 grant)
COHESIVE EUR 4,0 M (1,8 grant)
Open
GoF4R EUR 2,0 M
ST4RT EUR 1,0 M
My-TRAC EUR 3,5 M
future projects
IP5
To be awarded EUR 47,7 M
Lighthouse
SmartRail EUR 6,0 M
Members
FR8RAIL EUR 7,9 M (3,5 grant)
ARCC EUR 3,6 M (1,6 grant)
FFL4E EUR 3,4 M (1,5 grant)
FR8HUB EUR 9,9 M (4,4 grant)
Open
INNOWAG EUR 1,5 M
SMART EUR 1,0 M
DYNAFREIGHT EUR 1,0 M
DYNAFREIGHT EUR 1,0 M
future projects
CCA
To be awarded EUR 11,7 M
Lighthouse
Roll2Rail + In2rail EUR 6,1 M
Members
IMPACT-1 EUR 0,7 M (0,3 grant)
FINE 1 EUR 2,9 M (1,3 grant)
PLASA EUR 0,8 M (0,4 grant)
IMPACT-2 EUR 7,1 M (3,2 grant)
Open
NEAR2050 EUR 0,4 M
OPEUS EUR 0,8 M
DESTINATE EUR 1,0 M
GoSAFE RAIL EUR 1,3 M
GoSAFE RAIL EUR 1,3 M
future projects





6
DEPLOYMENT

Bringing about the technological and operational advances expected as a result of the S2R R&I activities requires active intervention. It does not happen by itself. Deployment of this complex array of innovation involves a coordinated effort to guarantee an adequate level of consistency and achieve the Single European Railway Area. This active role demands the capacity to recognise the steps required in the process, the funding needs, and the essential system of systems interaction and complexity of railway in all its segments and its components. This role should be as close as possible to the market, while providing the necessary independence under a joint governance.

Joint and coordinated deployment is predicated on a sound appreciation of the business case for change, both at corporate and societal levels; the requirements associated with standardisation and regulation; the timescales relating to opportunities for the insertion into the railway of new technical solutions; and a professional approach to risk management. As deployment will also rely on interfaces with a range of organisations beyond the railway, a collaboration strategy at the European level is also required.

6.1. THE BUSINESS VIEW

The economic benefits of delivering the S2R Programme targets have been identified by the impact assessment of the S2R JU proposal:

- An indirect leverage on industry R&I related to the development of industrial products exploiting H2020 innovations, worth up to EUR 9 billion in the period 2017-2023;
- Creation of additional GDP at EU level worth up to EUR 49 billion in the period 2015-2030, and spread among a large number of Member States;
- Creation of up to 140 000 additional jobs in the period 2015-2030;
- Additional exports worth up to EUR 20 billion in the period 2015-2030 thanks to the worldwide commercialisation of new rail technologies developed under H2020;
- Life-cycle cost savings worth around EUR 1 billion in the first 10 years and then, through continued implementation, worth around EUR 150 million per year.

Here below is the methodology that the S2R JU will implement in the years to come to produce the relevant business cases underpinning the deployment strategy of its Innovative Solutions.

Methodology for a societal business case

The Union's resources are limited. Goods and services are scarce resources, time is short, and good health and a clean environment require resources. Citizens and businesses' needs and wishes, on the other hand, appear to be substantial in many cases. Therefore, both society and the individual must always make choices and prioritise on how to make the best use of resources, even when the options have many effects that are uncertain and when price is unapparent/ unidentified. The method used to make socio-economic profitability assessments is a cost-benefit analysis (CBA).

These assessments are of course also relevant for the European rail sector. By looking at the overall effects of changes in the rail system, the true benefits can be analysed and defined. For S2R, this is a cornerstone to knowing what are the best measures and projects to meet the societal expectations of the future rail system.

To do this, a systematic approach is necessary. The profitability calculation of a CBA is a summary of the costs and revenue generated by an activity or project. The profitability estimate shows the net value of the resources produced / created (revenue) and the resources consumed / used (costs) and thus the net change of the total assets contributed by the activity / project in question. Resources means goods, services and other types of tangible and intangible assets, i.e. all that can be used for consumption or for production. A business profitability, private finance or government finance calculation aims to calculate the net value of the economic effects that affect an individual company, organisation or person. The socio-economic profitability calculation, on the other hand, aims at calculating the total net worth of all economic effects for all citizens in societ.

A CBA has methods for evaluating resources and benefits that are not market- prone, which business economics calculation methodologies do not have. In addition, the socio-economic analysis includes effects for all citizens, not just the effects that affect the organisation in question.

The socio-economic profitability calculation includes all positive and negative resource and utility effects of a measure, both direct and indirect. All effects on real resources should be included in the calculation, whether they are market-priced or not. For the effects that are not priced, a monetary valuation can be made

[18] Impact assessment : Proposal for a Council Regulation establishing the Shift2Rail Joint Undertaking SWD (2013) 535 final, Brussels, 16.12.2013

using estimated values-so-called shadow prices. The result that socioeconomic calculations show is the net contribution of an activity or project to the value of society's total real resource.

The analysis and results can be designed to show how the economic impact and net results are distributed across different sectors of society, regions, and / or different citizenship groups, e.g. gender, age groups or socioeconomic groups. However, in traditional CBA, no valuation of distribution effects is made. What distribution effects can be considered more or less desirable is basically a political issue. These types of analysis and values are therefore usually made in addition to the socio-economic analysis.

Socio-economic profitability assessments are made to determine if a measure is good for society or not, or to assess which measure is best among several possible. However, when using words like "good" and "best" in this context, it is important to be aware of the principles and conditions that are the basis for the analysis.

Socio-economic efficiency means that we have efficiency in production; that is to say, we produce the products that are demanded most by consumers and that production is at the lowest possible cost. Thus, socio-economic efficiency assumes that all that is produced has a value for the buyers / users at least equal to the cost of producing and providing. Socio-economic efficiency also means efficiency in consumption, i.e. the goods produced are consumed by people who ask for them the most.

Total socio-economic efficiency means that society's resources, in terms of goods and services, natural resources and the environment, time and energy, etc. are used in such a way that the total value of the total resources is as large as possible from the citizens' point of view. This means that the citizens' combined benefits of society's total resources should be as large as possible, both today and in the future. Socially profitable measures contribute to socio-economic efficiency, provided that all profitable measures are chosen or, if options are limited, the measures that are most economically viable.

A socio-economic analysis must contain both direct and indirect effects of the measure being evaluated, but on the other hand, do not include double counting. The direct and indirect effects can also be described as primary and secondary effects. The primary effects are effects on individuals, companies and organizations and parts of the public sector directly affected by the action options to be evaluated. The secondary effects are those that arise as a consequence of direct price, production and consumption changes.

A CBA should also include secondary effects of the evaluated measure. These effects consist of effects on other markets (secondary markets), i.e. markets other than those initially affected by the measure (primary markets). If the measure has significant effects on the main market, significant effects may also arise with partners, competitors and subcontractors.

6.2. STANDARDS AND REGULATORY NEEDS

> *"The innovation principle entails taking into account the impact on research and innovation in the process of developing and reviewing regulation in all policy domains, i.a. to ensure that EU regulation allows companies to enter markets more easily."* [19]

With this in mind, standards and standardisation have been highlighted under the Europe 2020 strategy as pivotal in supporting the EU's research and innovation activities, reaffirming the important role of standards for innovation as sources of competitiveness and in underpinning a smart, sustainable, and inclusive growth.

In general, standardisation is sought at EU level for the rail sector as it helps to:

- Eliminate technical barriers to trade and increase market access for all operators;
- Ensure interoperability and reduce the risk of "lock in" to proprietary solutions;
- Create certainty and confidence for users to adopt new technologies.

S2R focuses on innovation that will only take place if R&I, industrialisation, and a wide market uptake are combined. Therefore, the solutions that will be developed have to be highly interoperable and provide the required level of standardisation for long-term, easy, and cost efficient operation and maintainability of the railway system.

A high level of standardisation is needed at the interfaces of the internal constituents' subsystems which S2R can address in its different TDs to produce the expected system results, including, for example, procedures to implement innovatory upgrades throughout a product's life as a means to adapt to the obsolescence of technology or meet the final customers' changing needs. It will be the case, for instance, with the interfaces between the on-board train control and monitoring system (TCMS) and the connected train functions such as

[19] COM (2017) 479 final.

traction, doors control, brakes, etc.

A careful management of the functional interactions of the railway systems' different layers, from sub-system constituents up to the structural and non-structural sub-systems are therefore a condition to achieving significant progress in the operational reliability of the overall railway system.

Within the intricate European railway system, no change can be made to a subsystem without carefully checking the potential consequences for other stakeholders and, in many cases, without making changes to the European railways' body of established standards and regulations.

The very ambitious research results foreseen in S2R will need the wide agreement of the whole sector, starting with the specification of operational and maintenance constraints to innovation and continuing throughout the whole Programme. Consensus building will take the form of a collective appraisal of the results, leading to the specification of new voluntary interface standards and, in some cases, changes to standards and regulations belonging to the European railways Interoperability Directive.

For these reasons, S2R is closely working with the standardisation bodies in Europe and with the European Union Agency for Railways and actively contributing to the Rail Standardisation Coordination Platform for Europe (RASCOP), created by the European Commission (DG MOVE).

In addition, S2R is making use of its User Requirement, Implementation and Deployment working group to reach out to a wide range of partners able to represent all the actors in the marketplace, not just those who will be direct contributors to the S2R R&I activities.

The benefits of the foreseen integration of the standardisation aspects into the Research and Innovation process are numerous[20,21] and have been explored in past research projects, among which it:

- makes the results available to a wide range of stakeholders, offering opportunities to discuss, disseminate and promote project outcomes;
- helps to ensure that the project results will be used well beyond the duration of the project;
- is a powerful tool for bringing research and new technologies to the market.

However, while timely and well-designed standards can support innovation, premature, late, or inappropriate standards may have detrimental impacts on innovation. Therefore, the overall S2R Programme is benefiting from a standard focused harmonisation process across all its projects, and an overall standardisation S2R roadmap is being developed.

6.3. RISK MANAGEMENT

A standard assessment approach is followed for the systematic capture, analysis and mitigation of risks associated with the current S2R JU R&I Programme. A risk is understood as an undesired event or series of events which reduce confidence in the MAAP and, if taking place, may represent a potential obstacle towards delivering the timely, coordinated and efficient deployment of the foreseen activities. Risk management is an activity requiring regular attention and periodic updates to ensure that the monitoring procedures are working correctly. The annual activity report to the Shift2Rail Board contains such periodic risks updates.

The S2R risk registry is periodically updated by year-end. The current version (2017) is included in Table 2. Risks are identified according to their relevance, with appropriate mitigation plans described and aimed at reducing or eradicating the potential effects of any given risk.

The table below indicates the main risks associated with the S2R Programme activities and the financial administration of the JU, as well as the corresponding risk mitigation actions. It results from a Risk Management exercise performed within the JU during Q2 and Q3 2017.

20 Blind Knut : "The impact of Standardization and Standards on Innovation" – Manchester Institute of Innovation Research, February 2013.

21 CEN-CENELEC "How to link standardization with EU research projects: Advice for CEN and CENELEC Members"

Risk identified	Action Plan
Adequacy of the MAAP to the evolving needs of the users and stakeholders' expectations	During 2017, a revised version of Part 1 and 2 (now called Part A) of the MAAP will be finalized and Part 3 (now called Part B) maintained, taking into consideration the new top-down approach.
In accordance with the H2020 Rules of Participations, and considering the resources available on a yearly basis, the Programme shall be implemented through projects financed by annual grants. Largely, this may result in a piecemeal approach instead of innovative solutions towards a new integrated, connected and automated railway system. This may result in questioning the sound financial management of the implementation process through grants, especially with regards to Members selected through open competition and commitment.	Qualitative mitigating measures are identified and implemented to contain and monitor the identified risks. This is realised through the Governing Board (GB), System Integration Working Group (SIWG), and IP Steering Committees (SteCos) which maintain a Programme view compared to a piecemeal project view. During 2017, the sound financial management risks will be further assessed and possible adequate measures implemented accordingly.
Delays or inadequacies in the completion of activities in grants that are complementary or prerequisites to grants to be awarded under the Annual Work Plan (AWP) 2018 may result in an inability to implement activities under AWP 2018.	Ensure through program management the regular activity monitoring and reporting of projects, including gate reviews, to determine whether specific actions need to be taken with regard to a specific project (re-orientation, early closure, etc.)
Cross-project collaboration to achieve the Programme objectives at risk because of "silo" projects or IP approaches	Significant implication of SIWG + decoupling IP structure from AWP topics + further fostering use of common S2R Cooperation Tool and sharing functionalities
S2R JU Members fail to deliver on additional activities.	Additional activities plan is contained in the Membership agreement. Work with the Members on preparation and implementation of the certification and reporting requirements.
Lack of adequate dissemination of results may result in vague information to the end-user/ interested parties and could compromise the JU impact.	The JU is working towards a joint dissemination plan, monitoring the dissemination actions and promoting project results.
There is a risk of the projects underspending the resources available.	Together with the Other Members, the JU has put in place reporting and monitoring systems that should detect any risk of underspending and take the necessary corrective measures.
TDs not/partially achieved because of: - lack of resources (staff, money, assets etc.) - Members priorities/merge/ stepping out - insufficient or late delivery/ input from the projects	Proper planning and regular follow up at IPSteCo/SIWG + Projects control gates + regular reporting to GB.
Demonstrations not interoperable because they represent a single company solution	Collaborative approach in Grant Agreement (GA) + Projects control gates + regular reporting to GB.
Projects development not aligned with S2R Programme	Programme perspective in GA + regular follow-up at IPSteCo/ SIWG + regular reporting to GB.
Operational demonstrations not/partially achieved because of difficulties in obtaining Authorisation(s)	Planning anticipation and regular follow-up at IPSteCo/SIWG + ERA involvement + regular reporting to GB.
S2R solutions not reaching the market due to lack of coordination and resources at deployment level	Investigate possible instrument to support deployment at EU level and implement JU strategy/ support
Partial or limited stakeholders' (including Members) acceptance of S2R solutions	Decision made on consensus based approach in IP SteCo/ SIWG/GB + involvement of URID-WG (how the S2R solutions are accepted - develop strategy)
Significant cut in EU budget	The JU Membership shall put in place all the measures to provide all the elements to the budget authority to reduce such a risk
Governance: organisation complexity that impacts S2R JU global objectives	On the one hand, the S2R JU shall focus on delivering the Programme results and, on the other hand, assess and put in place measures that can make its governance more effective and efficient
Turnover of staff and insufficient number and/or quality of applications due contract conditions	Within the budget constraints, prepare a career plan for staff. Ensure business continuity
Lack of back-up for JU key function	Replacement plan (back-up) where possible including through external support (interim, expert, outsourcing)

6.4. COLLABORATION STRATEGY WITH OTHER ORGANISATIONS

In order to achieve its Programme and the task to "manage all rail-focused research and innovation actions co-funded by the Union , the S2R JU is working closely with European Commission DG MOVE, as well as DG RTD, the European Agency for Railways (ERA), the European GNSS Agency (GSA), and other Union bodies and Agencies.

The relation between the S2R JU and the Commission is established in the S2R Regulations as well as in the relevant delegation agreement and materializes in daily exchanges covering all aspects of the S2R Programme and the railway transport policy.

With particular regard to ERA, the S2R JU should "bring in the experience and expertise of (ERA) on issues relating to interoperability and safety" measures of cooperation. In the same manner, the relationship between ERA and the S2R JU shall be interpreted in light of the role of the JU *"to manage all rail-focused research and innovation actions co-funded by the Union".*

In order to ensure that the results from the S2R projects do not encounter a regulatory blocking point because of their novelty (as far as safety and interoperability are concerned, mainly through the integration with the rail Technical Specification for Interoperability - TSI), the S2R JU has defined with ERA and DG MOVE a process for collaboration at project level.

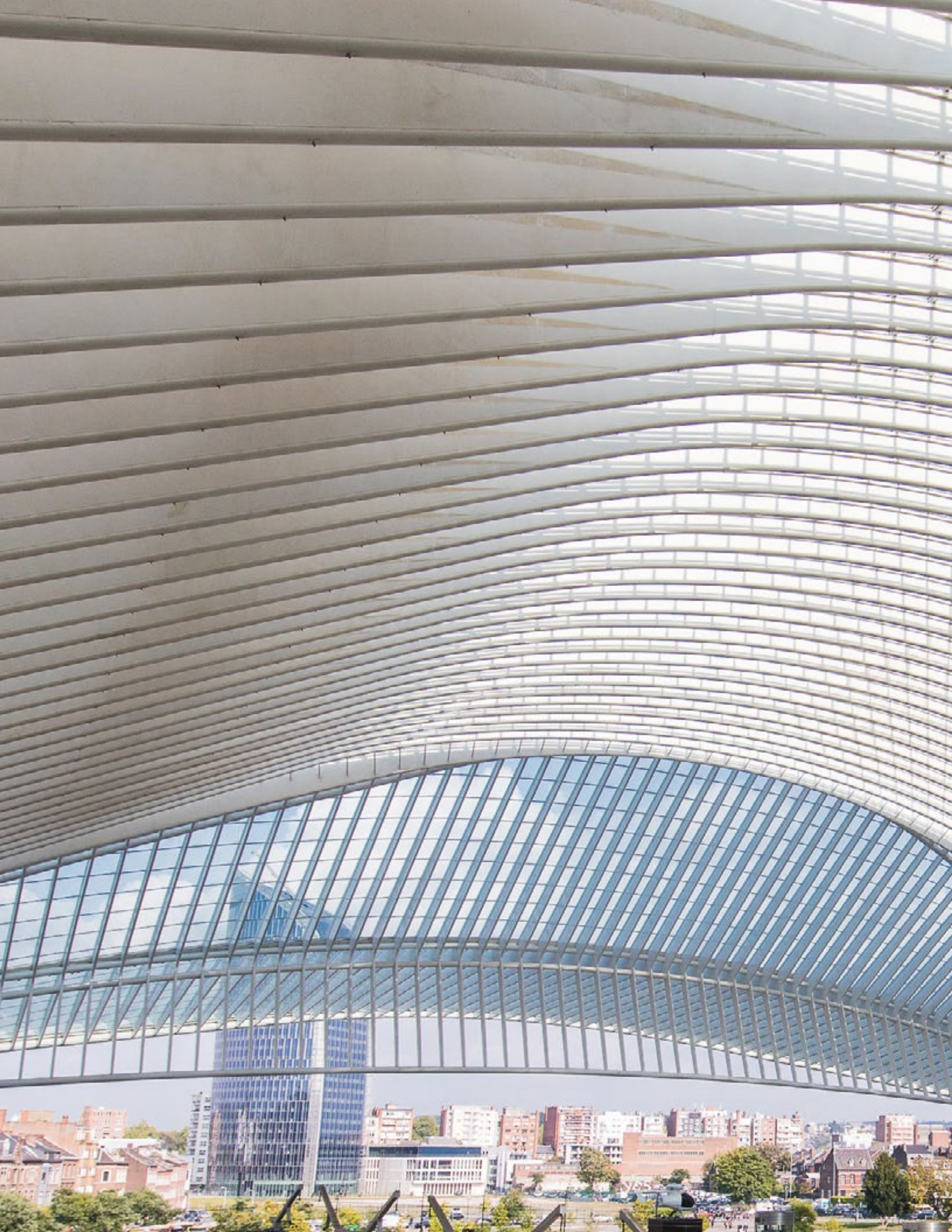
In order to establish relations with different users of or entities involved with railway systems, the S2R JU has set up two main working groups:

- the User Requirements Working Group(s) is composed of S2R JU Members and non-Members to assist the JU in ensuring that technical solutions developed within S2R meet these specific needs of all relevant end users;
- the Implementation and Deployment Working Group(s) is composed of S2R JU Members and non-Members to test the operational reliability of the results of Shift2Rail and thereby contribute to a more rapid uptake and large-scale deployment of the solutions developed through the Shift2Rail activities.

These two working groups have been clustered together for the time being (URID-WG).

In addition, the S2R JU maintain different bilateral relations with the railway sector stakeholders and their representatives (UNIFE, UIC, UITP, CER, UIRR, CEN/CENELEC, ETSI, etc.).

[22] Article 2(i) of the S2R Statutes annexed to the S2R Regulation.



7

A MAINTAINED VISION OF THE RAILWAY

The acceleration in new technologies brought by different sciences, building upon the experience in different sectors, requires that the MAAP is regularly updated and maintained, while not jeopardizing the focus to deliver results for passengers and freight business.

The maintenance and update of the MAAP results from the contribution of the stakeholders of the railway value chain, within the S2R JU Membership and beyond. It is expected that the present document would be subject to review at the Horizon 2020; by then, the initial results of S2R will be demonstrated, and they will pave the way to the deployment of the Innovative Solutions available.

In addition to the R&I activities beyond 2020, a critical area in the MAAP will be a more specific deployment strategy as part of an overall system architecture supported by quantified business cases. The market uptake and deployment of the S2R Innovative Solutions will be essential to delivering the railway system of the future as the backbone of connected inter-modal sustainable mobility for passengers and goods.

www.shift2rail.org

Shift2Rail_JU

Shift2Rail Joint Undertaking

Shift2Rail Joint Undertaking
White Atrium building, 2nd Floor
Avenue de la Toison d'Or 56-60 • B1060
Brussels/Belgium

Horizon 2020
European Union Funding
for Research & Innovation