



DRAFT FOR PRESENTATION AND DISCUSSION

Multi-Annual Action Plan [MAAP]

Executive View

Part A

Brussels, 22 May 2017

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 export of services. The railway has for centuries been the backbone of transport, instrumental in the different industrial revolutions. Today, although the railway remains at the heart of transport, it needs radical change to maintain and improve its role to become the 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.

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.

[we need to put two pictures one for the list of capabilities and one for the detailed vision in the final editing]

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 Programme¹ and the deployment activities to be performed 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.

Addressing the challenges opens three opportunities for the railway:

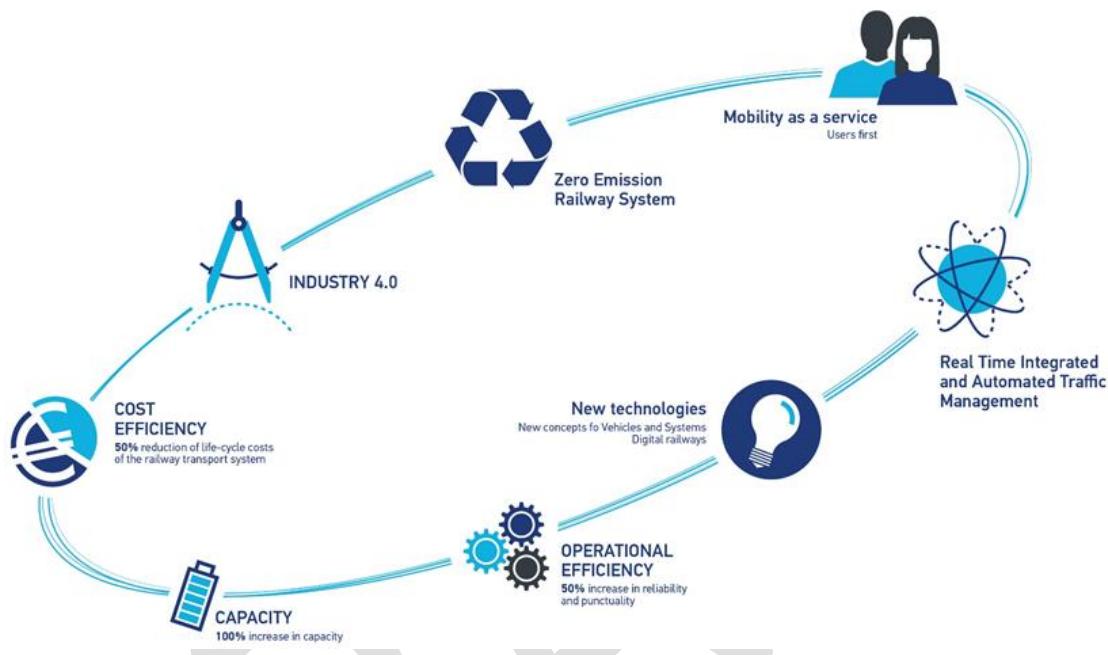
1. To become the backbone of current and future mobility concepts (e.g. mobility as a service-MaaS) and on-demand future logistics;
2. To identify and establish new market segments for exploitation;
3. To enhance the overall competitiveness of the industry, both in Europe and globally.

This is what the Regulation tasks the S2R JU to do when requesting it to manage all rail-focused research and innovation actions co-funded by the 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 against, *inter alia*, 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;

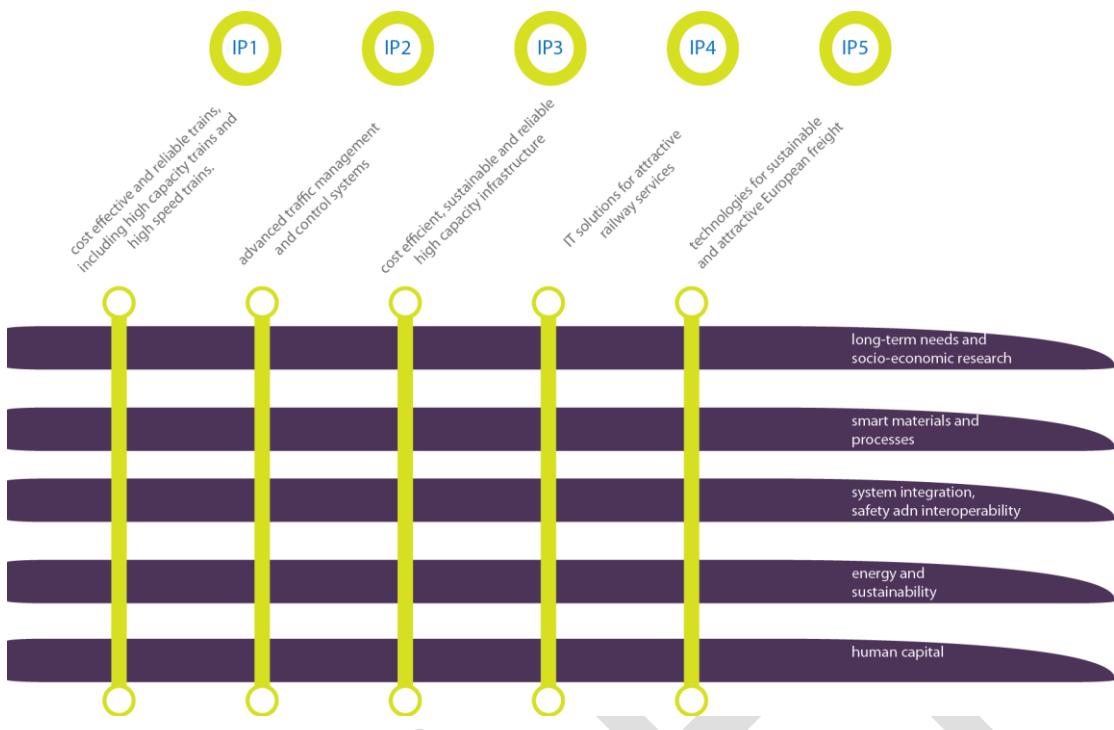
¹ The S2R Programme runs between 2014 up to 2020 with the possibility of final implementation and phasing out by 2024.

- 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.

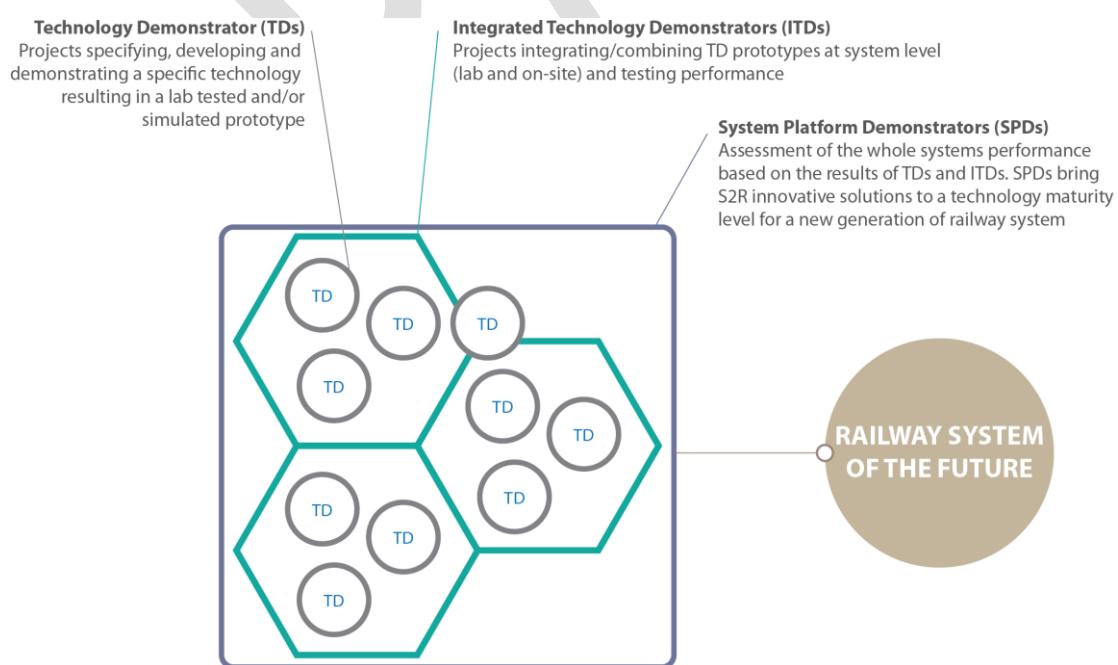


Developing the Innovation Capabilities requires a coordinated effort among different rail and non-rail stakeholders to drive innovation at levels in Europe. The S2R JU and its Programme are designed to make a decisive contribution to delivering the essential knowledge and innovation that will provide 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 resulting into the Innovation Capabilities) and system platform demonstrators (SPDs).



By end of 2017, € 333.2² m has already been invested in R&I activities by the partnership.

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 foresee, accordingly to the impact assessment³ 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.

² Including the Lighthouse Projects awarded by the European Commission in 2015 and part of the S2R Initiative in accordance with the S2R Regulation for the amount of

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



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, and that already today provides 400.000 high skilled jobs within European manufacturing industries, including numerous SMEs. The railway sector overall, including maintenance and operations, is responsible for more than 1 million direct and 1.2 million indirect jobs in the EU.

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.

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1. Introduction

1.1. General policy context

1.1.1. European strategic vision for an integrated transport system

The 2015 S2R MP⁴ 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 Paper⁵ ("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 Paper⁶. 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 new potentials, particularly due to automation and digitalisation.

⁴ <http://ec.europa.eu/transport/sites/transport/files/modes/rail/doc/2015-03-31-decisionn4-2015-adoption-s2r-masterplan.pdf>

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.

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 ton-km (+87%) compared to 2005
	Deployment of ERTMS on the European Core Network by 2030
	By 2050, connect all seaports to the rail freight system
	Rail freight corridors as the backbone of the EU freight transport system
For Urban Mobility	Halve the use of 'conventionally-fuelled' cars in urban transport by 2030; phase them out in cities by 2050
	Achieve essentially 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

1.1.2. Reindustrialisation

The S2R JU also has an important role in supporting the European Commission's policy on reindustrialisation⁷, 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

⁷ Communication For a European Industrial Renaissance (Jan 2014)

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. This goal remains as relevant today as it was then.

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'⁸ 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 various major proposals that together form the Fourth Railway Package⁹, without which the European single market cannot be complete. The proposals were adopted by the Commission in January 2013 and aim to remove remaining administrative, technical and regulatory obstacles that are holding back the rail sector in terms of market opening 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,

⁸ Directive 2012/34/EU of the European Parliament and of the Council of 21 November 2012 establishing a Single European Railway Area (recast)

⁹ The Fourth Railway Package – Completing the single European railway area to foster European competitiveness and growth, COM (2013) 25 final

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 preconizes 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*".

The 2016 review of the White Paper identifies the progress being made in the legislative adoption of the fourth railway package with the completion of the following measures:

- Provisional inter- institutional agreement on the "market" pillar on 19 April 2016 related to the opening of passenger domestic market, including tendering of Public Service Obligations (PSO) and governance aspects
- "Technical" pillar (Regulation 2016/796, Directive 2016/797 and Directive 2016/798) adopted on 11 May 2016 related to single vehicle authorisation, single railway undertaking safety certification, reinforcement of the role of ERA;
- "Technical" (Regulation 2016/796, Directive 2016/797 and Directive 2016/798) adopted on 11 May 2016 related to non-discriminatory access to rail infrastructure, including rail related services through structural separation

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, and it identifies the associated set of twelve new 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 focus 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 European wide system of systems approach that is novel for the sector.

Part A links the S2R MP¹⁰ and the MAAP as indicated below (Fig. 1).

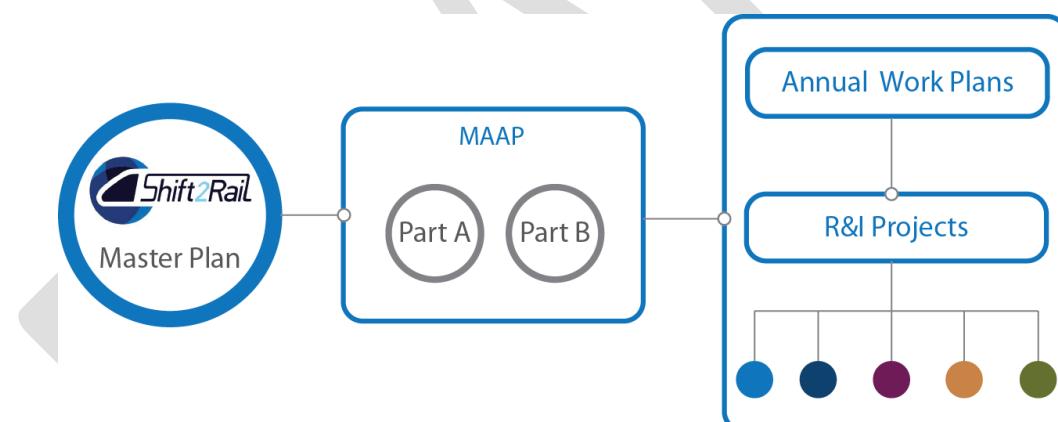
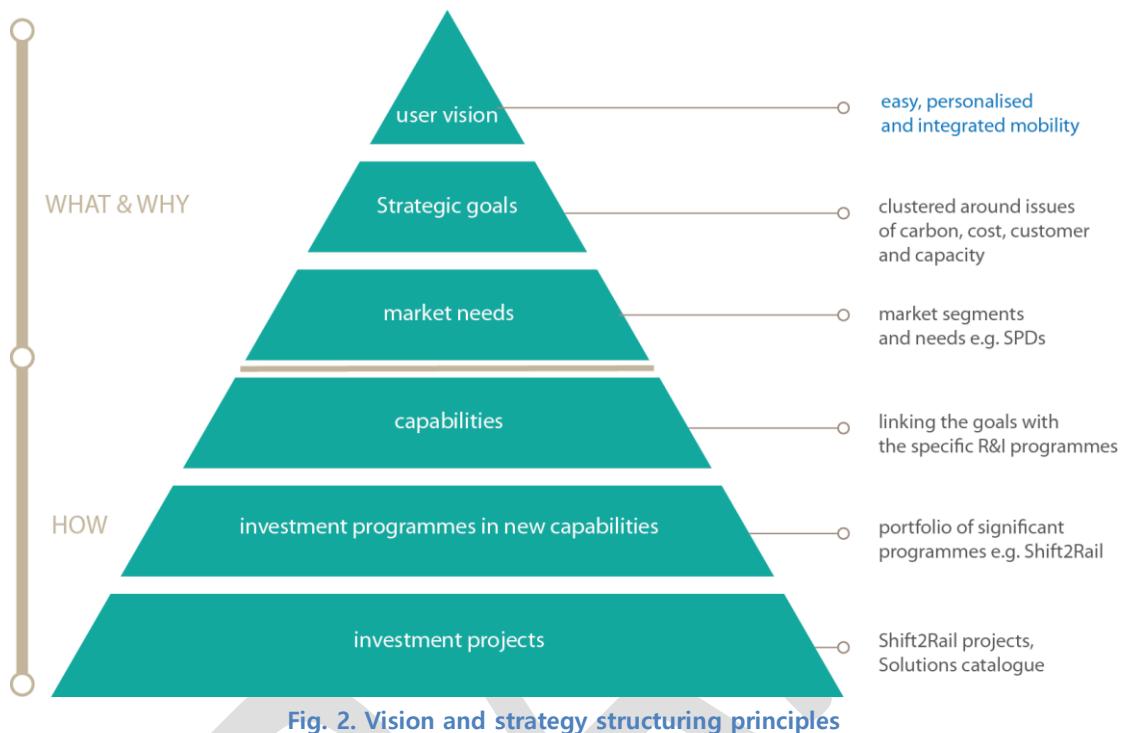


Fig. 1. Shift2Rail framework

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

¹⁰ 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 N° 4/2015)

The Innovation Capability delivery strategy and associated implementation plan requires full cooperation between all stakeholders to prioritise and align efforts and resources. The fundamental rationale of this process is illustrated in Fig. 2.



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.

Strengthening the role of rail in the European transport system and the global competitiveness of European Industry



Fig. 3. Key eight 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 set it apart from its competitors - for instance its abilities to provide mass transit, journey comfort, safety, land use, a low carbon footprint and energy efficiency.

By addressing the challenges identified above, it can open three areas of opportunity (Fig. 4):

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



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

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 the interface. 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 challenge creates an opportunity to complete 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 the national systems to become part of the broader European mobility system with all the benefits that this brings.

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. 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 increase 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 European 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 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 position and esteem of the European sector in the global standings 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 e.g. automation and electrification of the 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:

[To be worked out with the CCA/ KPIs activities in accordance with the relevant project plans]

- 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.

The S2R Partnership¹¹, reflecting the rail sector's good understanding of its customers' bespoke 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 – such as mass transit, transport of heavy loads and efficient use of space.

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.^{12 13}. 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

¹¹ S2R partnership includes also the different S2R advisory bodies and working groups.

¹² "Assessment of global megatrends - an update", European Environmental Agency (EEA), February 2017

¹³ 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.

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 and car-sharing), 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. 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, but as agreed at global level, further improvement is expected in line with the targets of COP21¹⁴. Noise emission also remains one of the key challenges that the railway system must address.

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

¹⁴ 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.

Further adoption by the European citizen of an available, performing and attractive rail renewed 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 the people, including those who traditionally have found it difficult to use transport systems. This will provide freedom for all people to participate to the full 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.

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 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 the 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 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. 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 hitherto, based on trains running closer together, 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, allows always on time delivery, security of supply, lower inventory and therefore system costs. The customer choice for train as key mode of transport contributes to breaking down the barriers between the multiple modes needed to deliver goods. This is realized through synchronisation with train movements on the network and with the road mode in pre- and post-haulage and 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 delivering of the S2R programme.

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 Capabilities¹⁵ (Fig. 5) described below have digitalisation and automation at their core. They include one that is non-technical,

¹⁵ These capabilities have been developed in coordination with the UIC RICG

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.

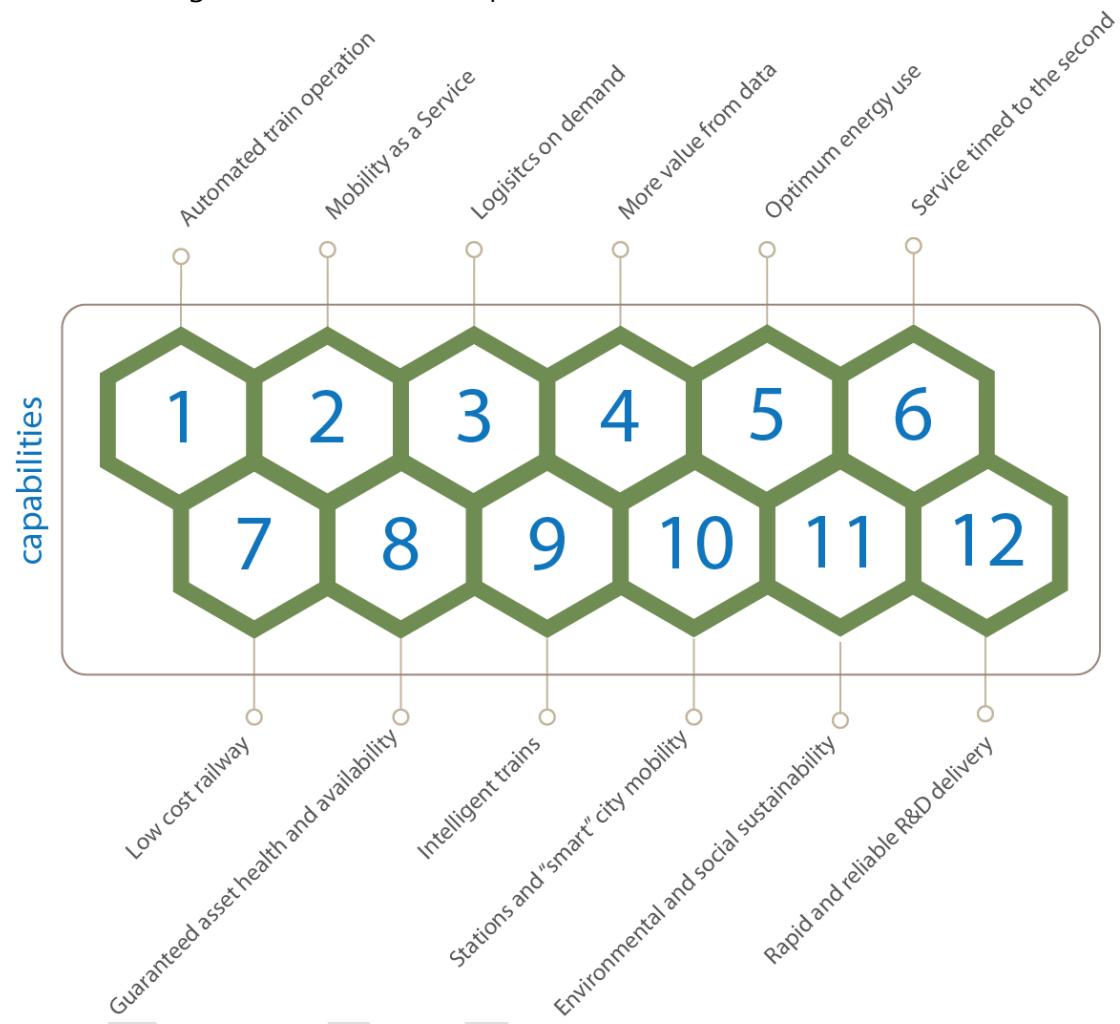


Fig. 5. Twelve capabilities required for the realisation of the Shift2Rail vision

Capability 1_Automated train operation.

Trains are able to operate themselves and run closer together based on an automated train operation system, boosting the capacity significantly on existing lines. 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

Capability 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_** *Superior passenger experience and comfort as a key value compared to other transport modes*

Capability 3_Logistics on demand

Logistics services are driven by customer demand, with freight moved reliably in wagons 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

Capability 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 Intelligent (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.

Capability 5_Optimum energy use

Railways maintain their position as the most environment-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.

Capability 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

Capability 7 Low cost railway

New models to deliver efficient and affordable infrastructure, rolling stock and railway operation allow the rail mode to be viable in areas of low demand and to compete for new transport links. Design, service solutions, technologies draw inspiration from other sectors such as light rail, automotive and aviation.

- 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.

Capability 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 a robotic 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

Capability 9_Intelligent trains

Intelligent trains are aware of themselves, their passengers/loads and their surroundings, knowing where they need to be and when, and 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 is 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.

Capability 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, where individual transport modes, including public transport and long-distance rail transport, are physically connected. New 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 way finding, 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

Capability 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 enable the railway to move towards 'zero-waste' operation
- 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

Capability 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, remove barriers to the adoption of new technologies and decrease 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, 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.

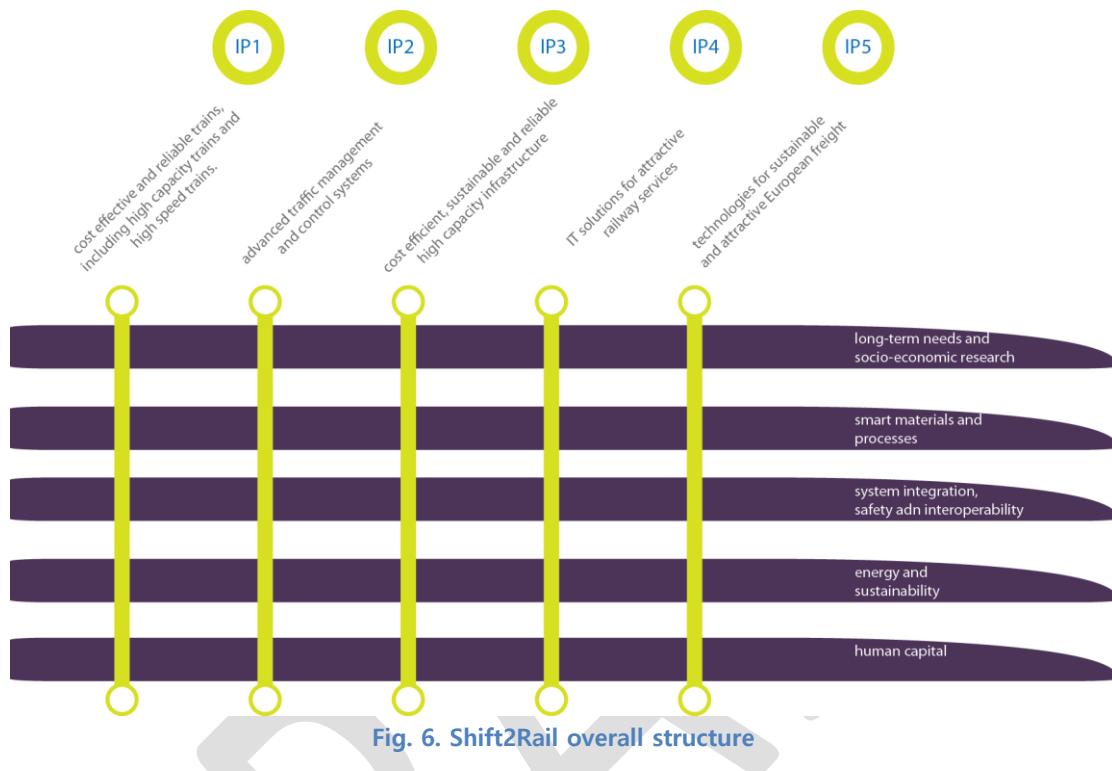
12D_ Agile development approaches, Labs, Hackathons, early involvement of customers are the elements of customer centric innovations. Open-labs invite end-users/customers to be part of the innovation process.

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 (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.

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 are being created;
- to quantify the impact of each new technology, either alone or in combination with other innovations;
- to provide a first estimate of the potential for improvement in the sector at multiple levels of the transport network (regional, national and EU);
- to enhance the perceived innovation potential of the sector and
- to 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).

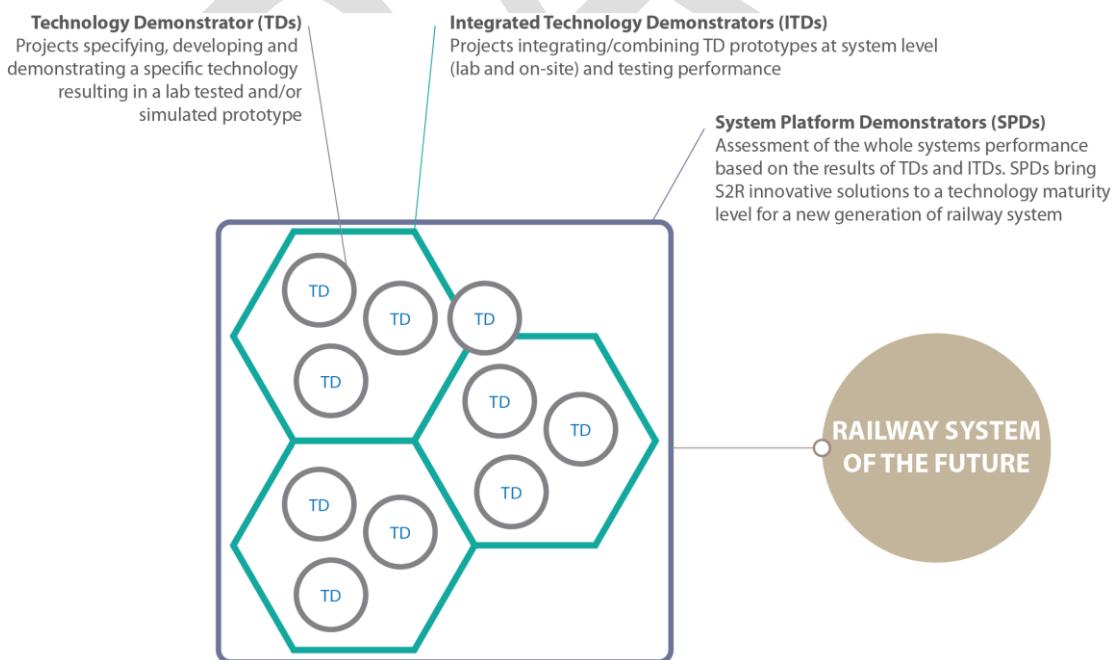


Fig. 7. Structure of Shift2Rail demonstrators

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 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 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 through 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).

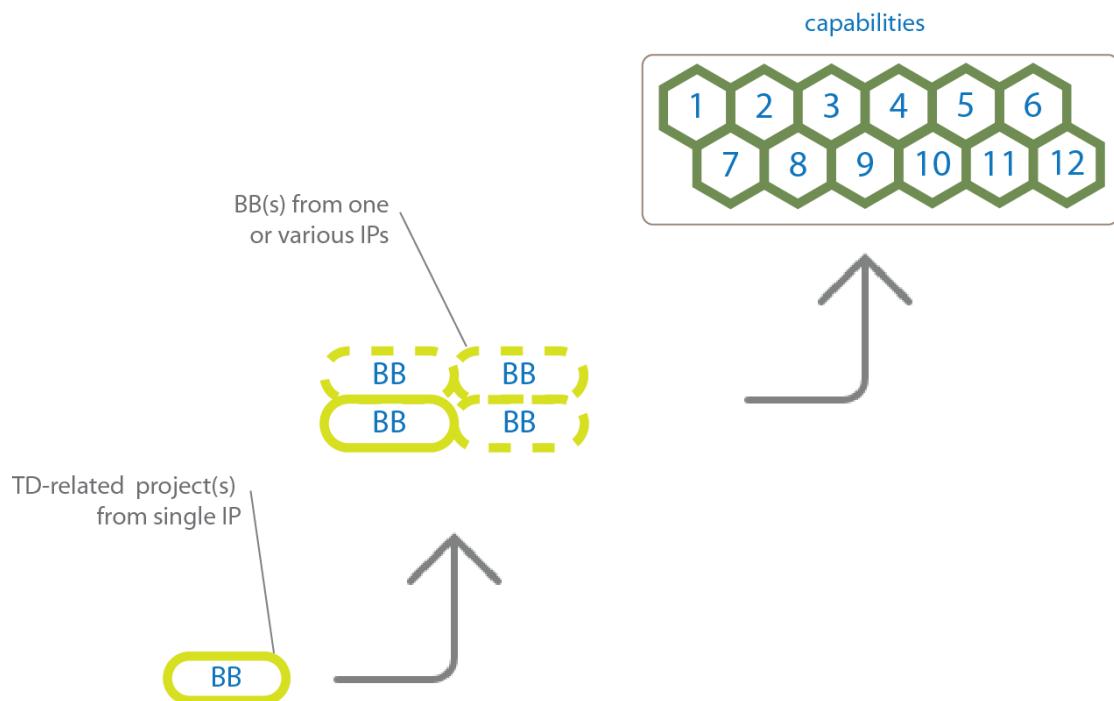


Fig. 8. Building blocks approach to capabilities

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.

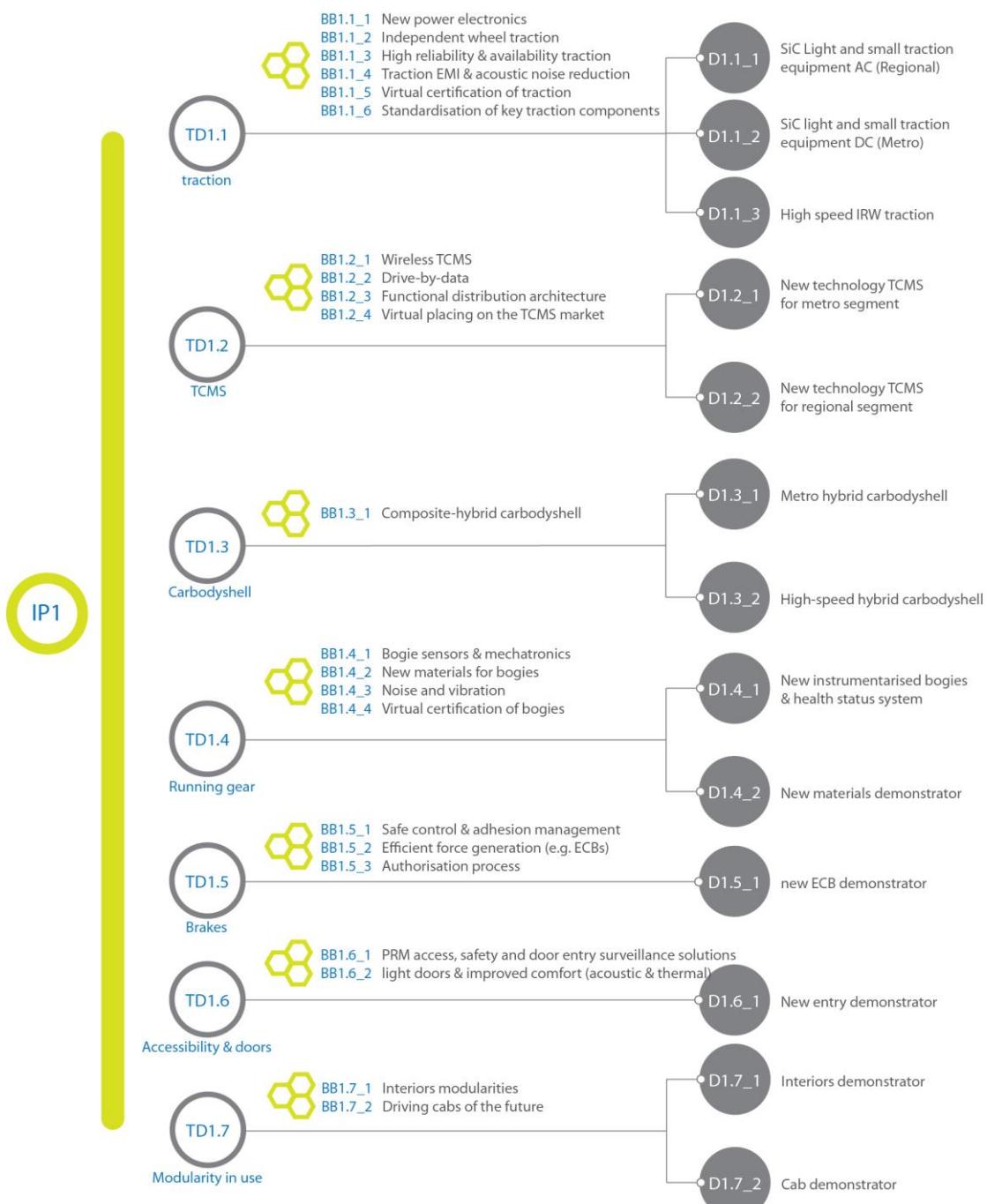


Fig. 9. IP1 Building blocks (BBs) and deliverables associated with its Technology demonstrators (TDs)

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

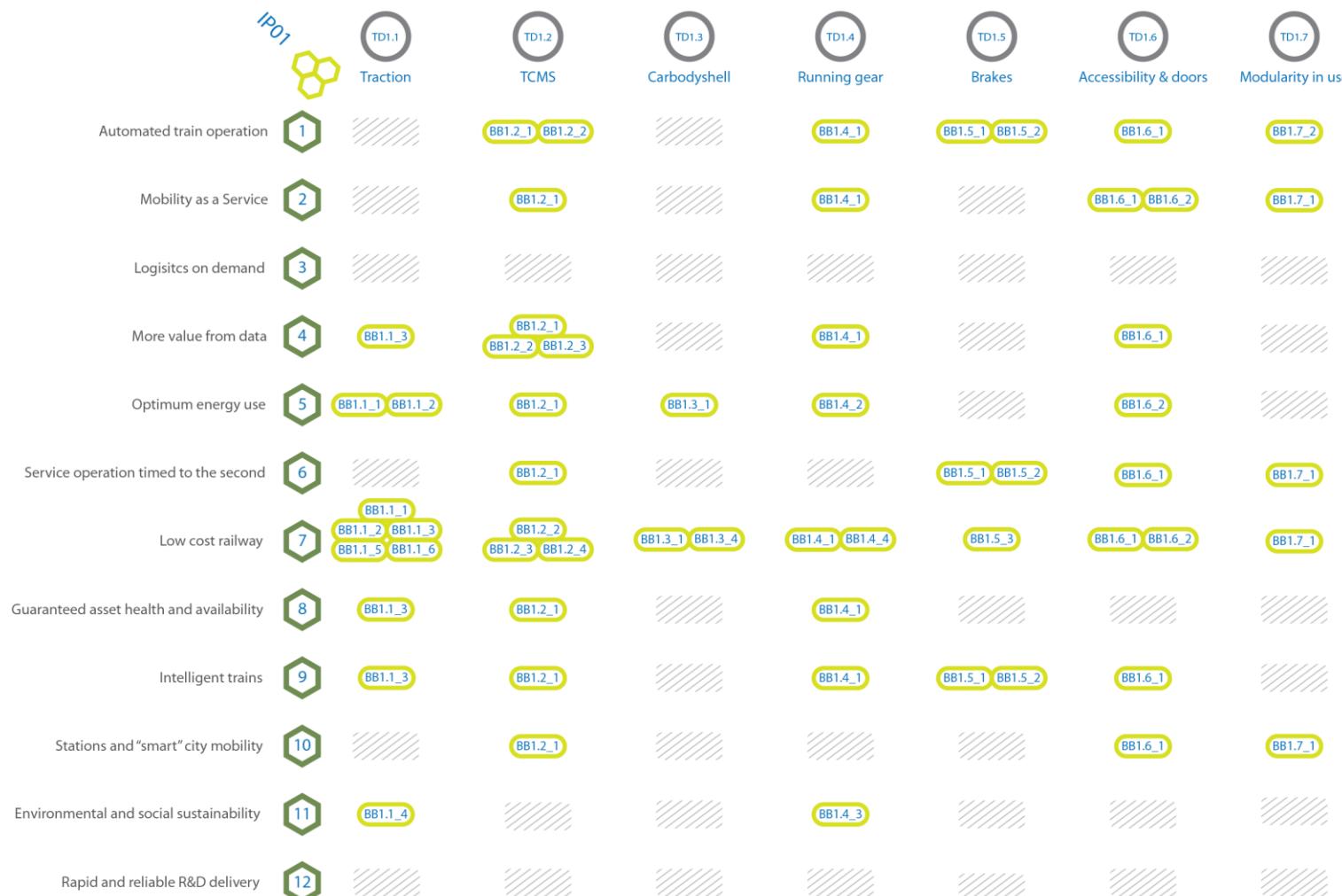
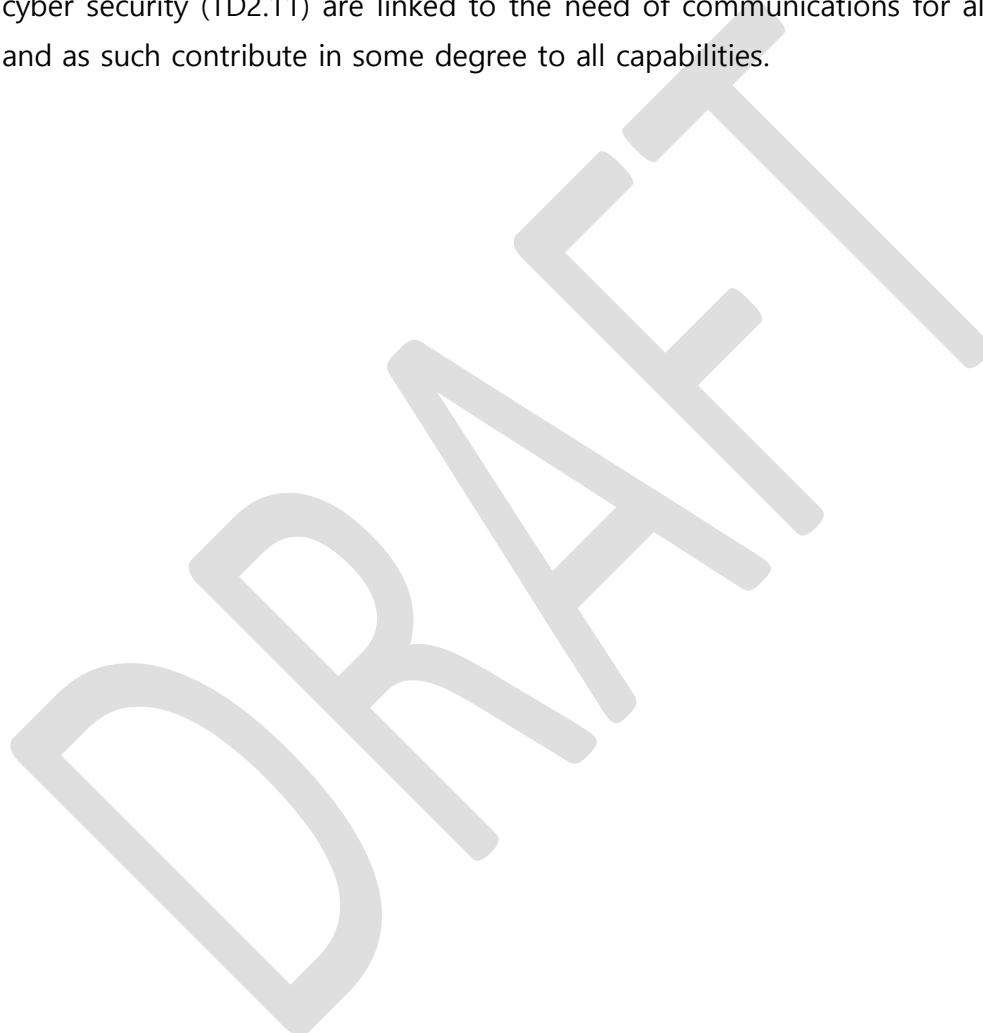


Fig. 10. IP1 alignment of building blocks (BBs) with capabilities

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.



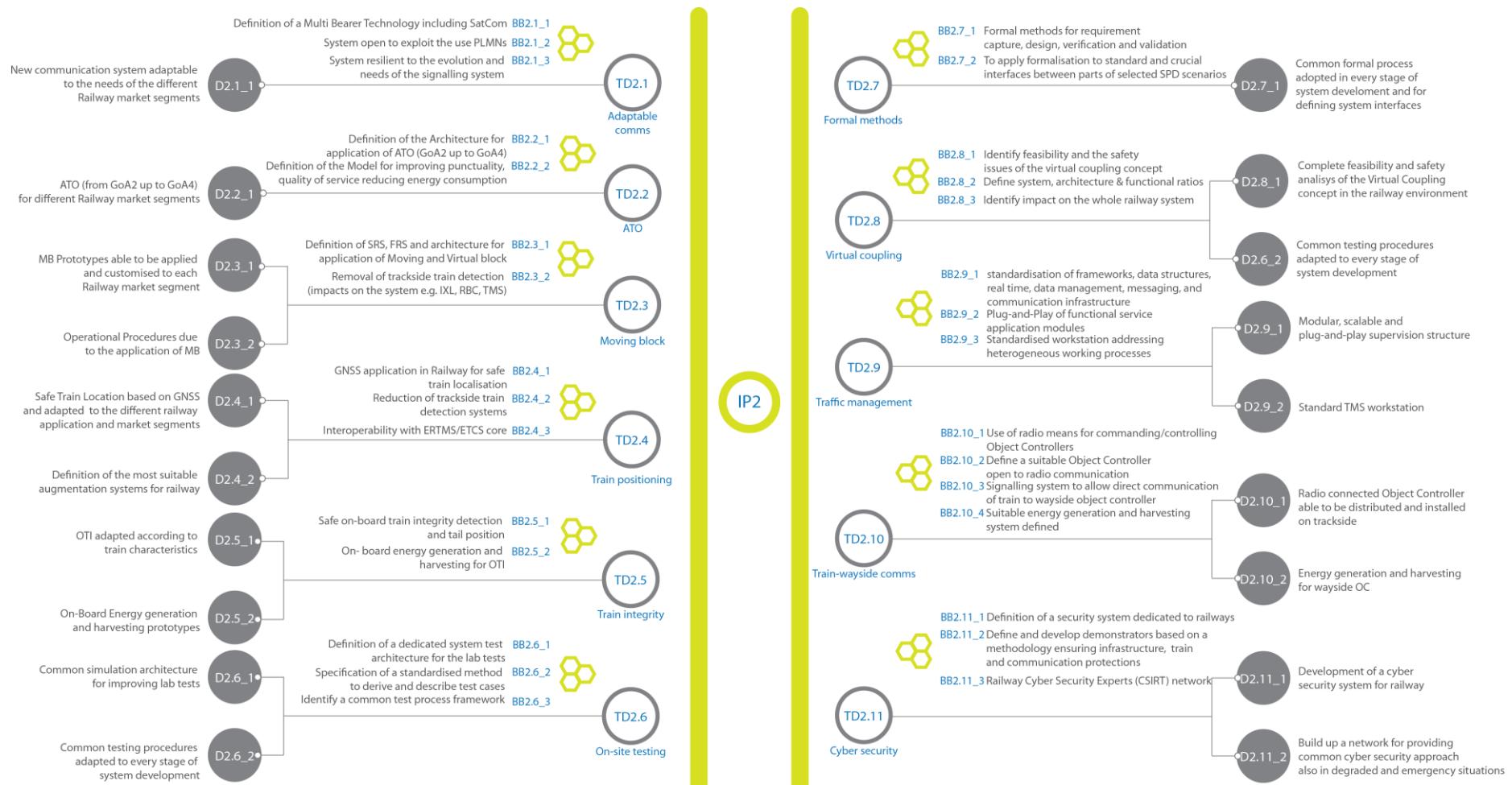


Fig. 11. IP2 Building blocks (BBs) and deliverables associated with its Technology demonstrators (TDs)

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

DRAFT

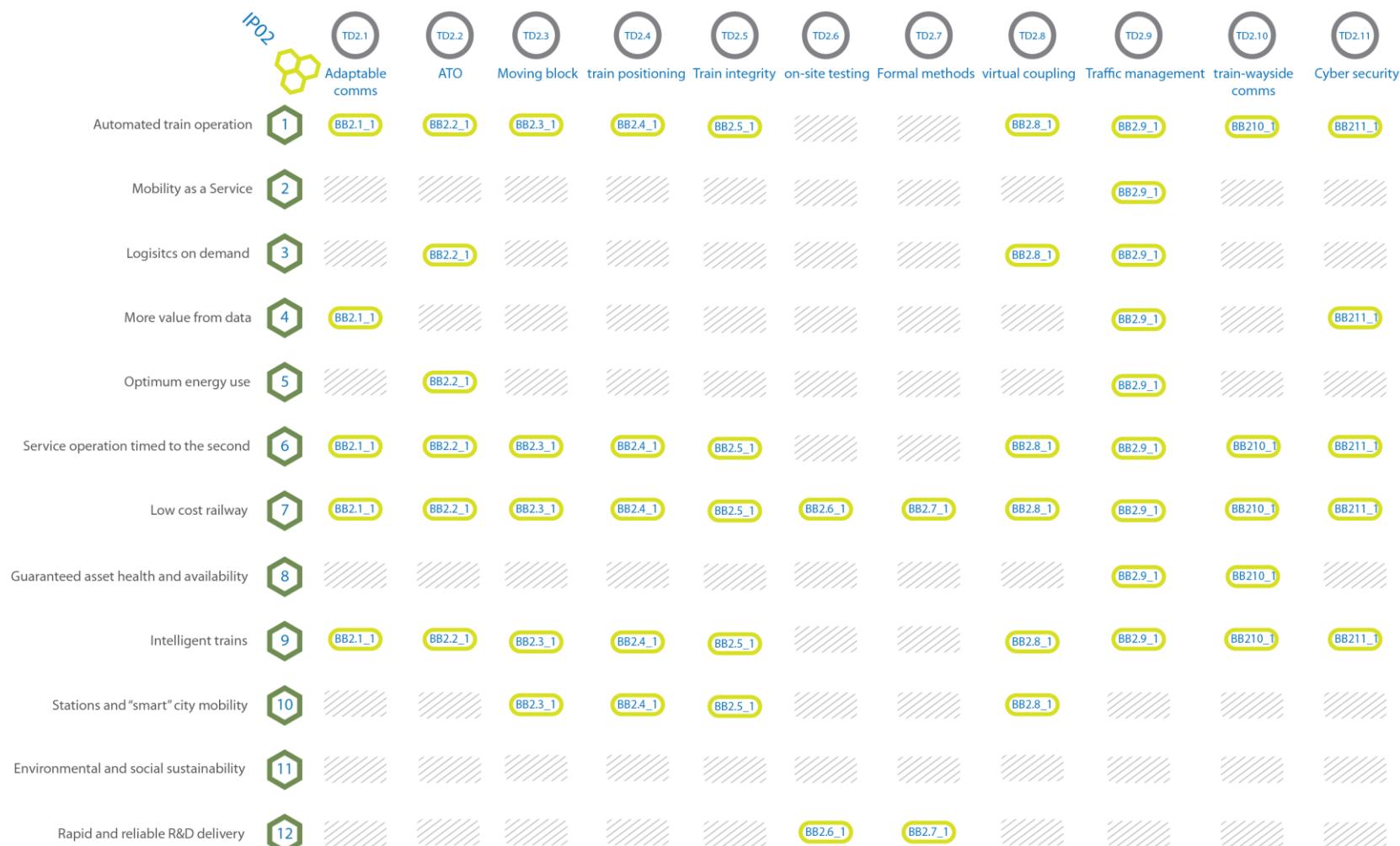


Fig. 12. IP2 alignment of building blocks (BBs) with capabilities

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 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 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.

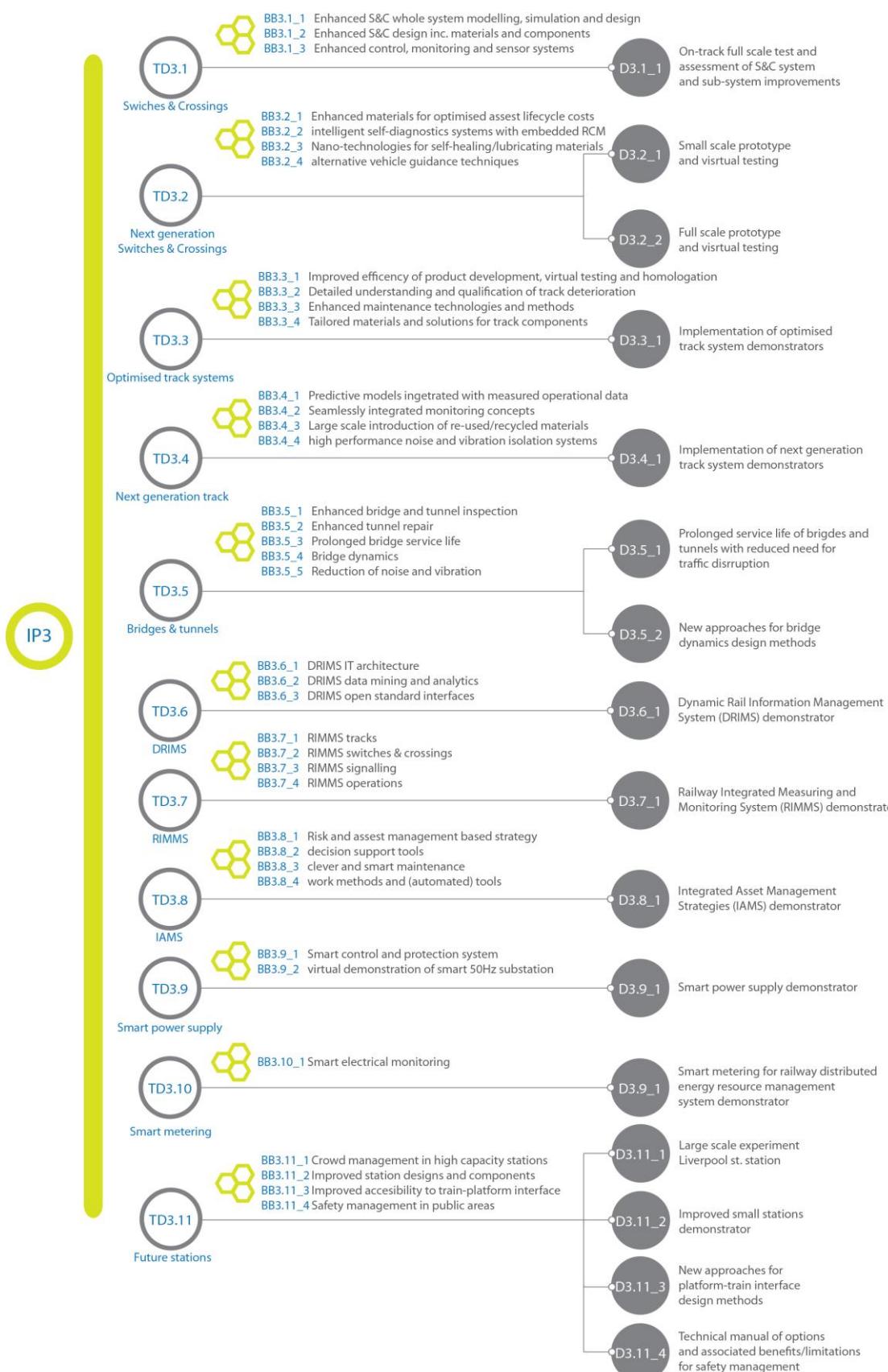


Fig. 13. IP3 Building blocks (BBs) and deliverables associated with its Technology demonstrators (TDs)

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

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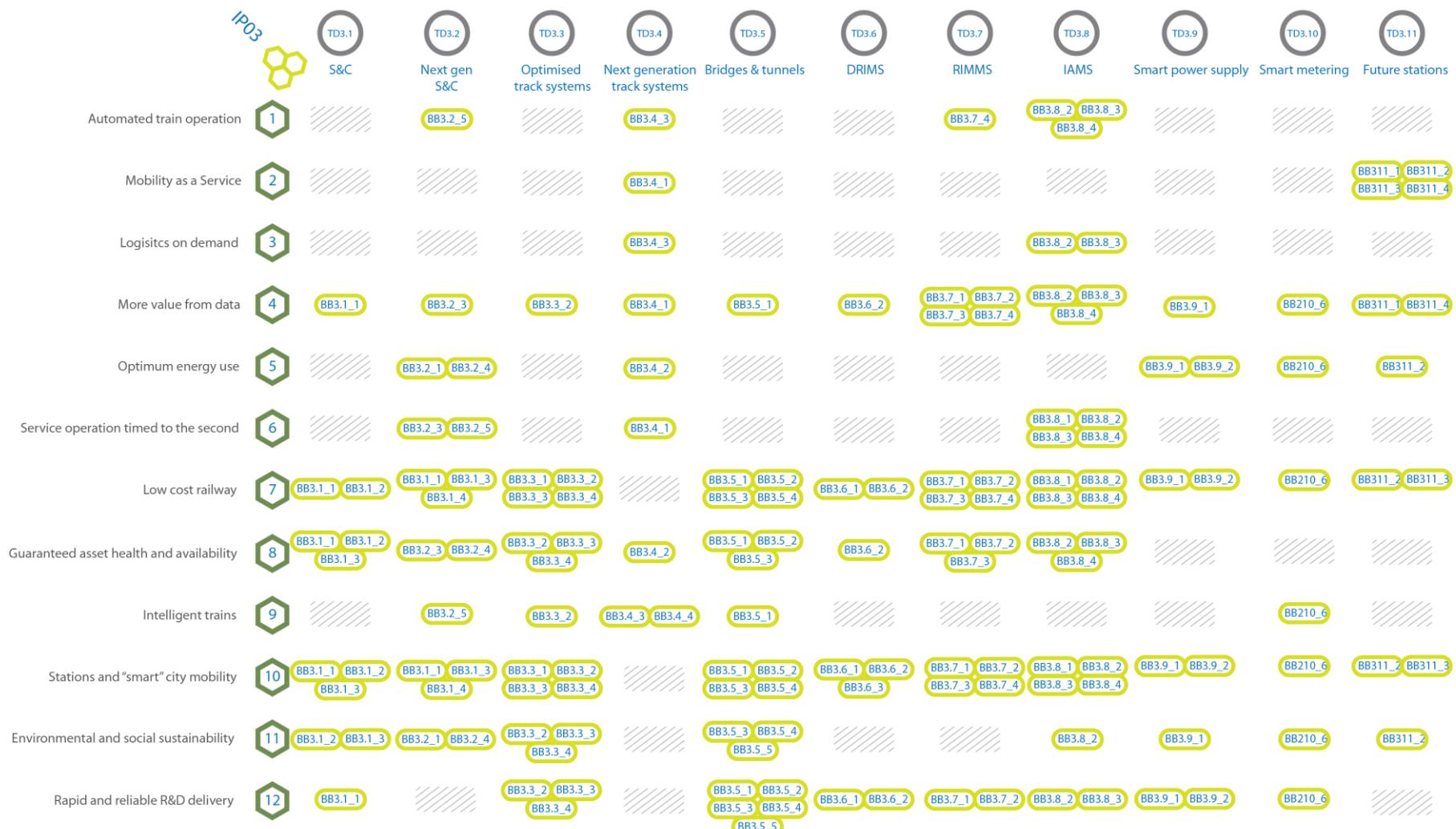


Fig. 14. IP3 alignment of building blocks (BBs) with capabilities

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.

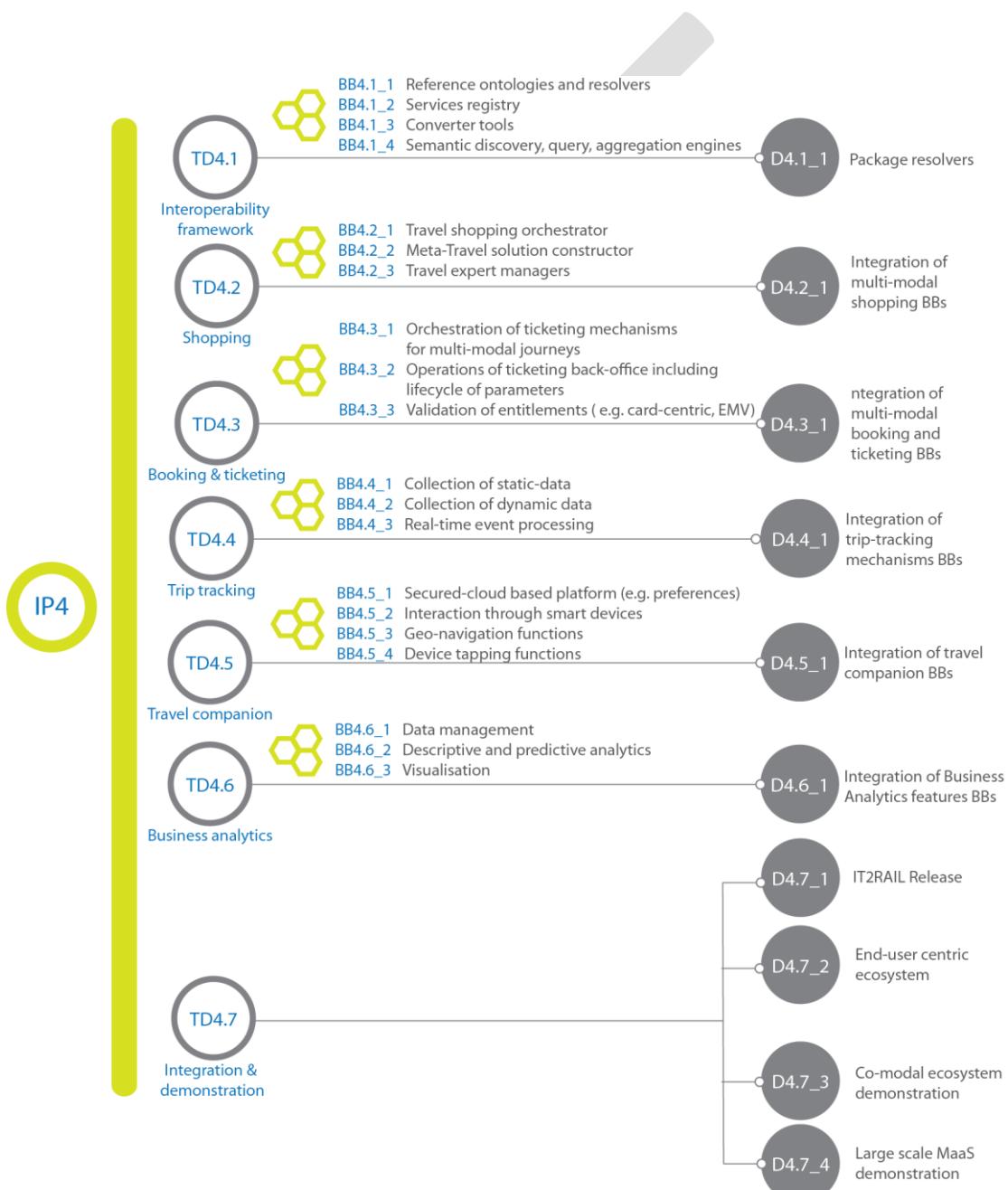


Fig. 15. IP4 Building blocks (BBs) and deliverables associated with its Technology demonstrators (TDs)

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

DRAFT

	IP04	TD4.1	TD4.2	TD4.3	TD4.4	TD4.5	TD4.6	TD4.7
	Interoperability framework	Shopping	Booking & ticketing	Trip tracking	Travel companion	Business analytics	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 Capability 2
Logistics 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 Capability 4
Optimum energy use	5							
Service operation timed to the second	6							
Low cost railway	7							
Guaranteed asset health and availability	8							
Intelligent trains	9							
Stations and "smart" city mobility	10							
Environmental and social sustainability	11							
Rapid and reliable R&D delivery	12							

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:

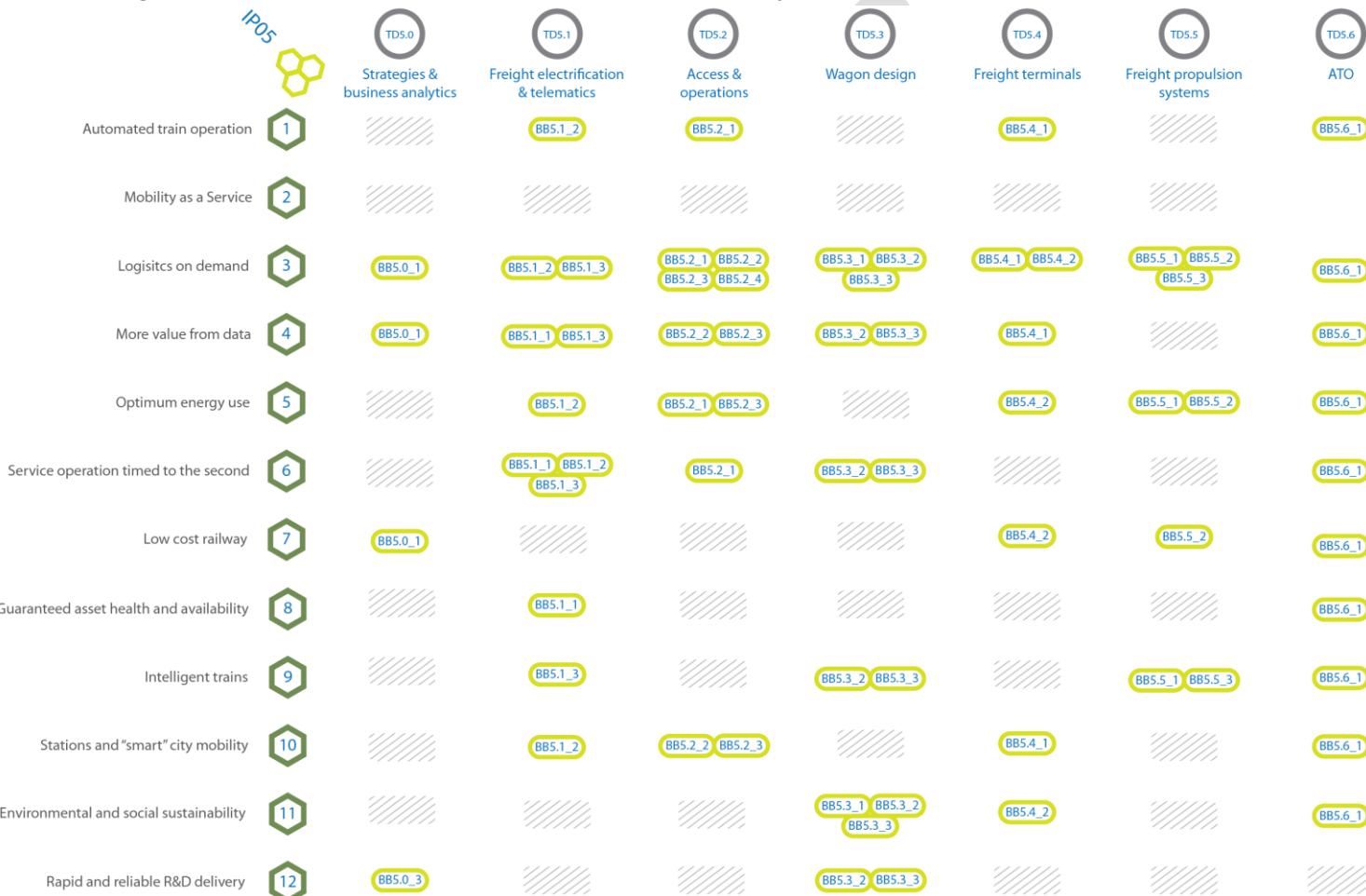


Fig. 18. IP5 alignment of building blocks (BBs) with capabilities

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.

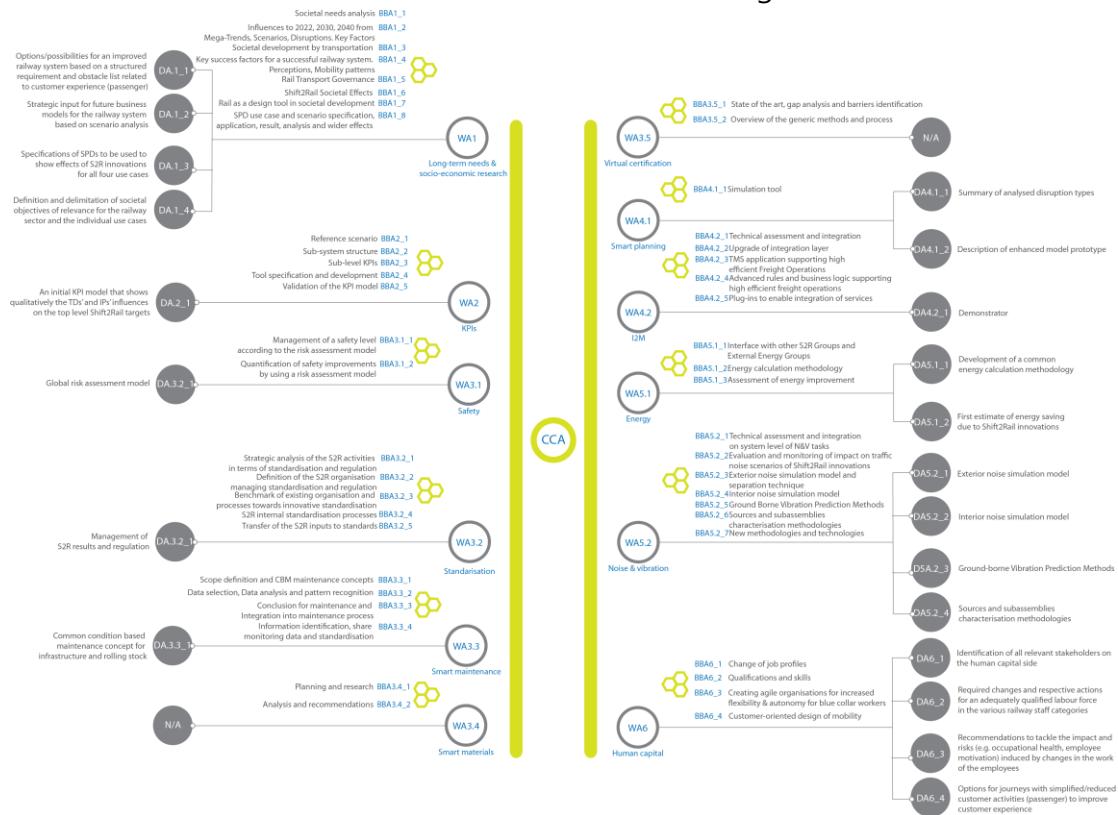


Fig. 19. IP4 Building blocks (BBs) and deliverables associated

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

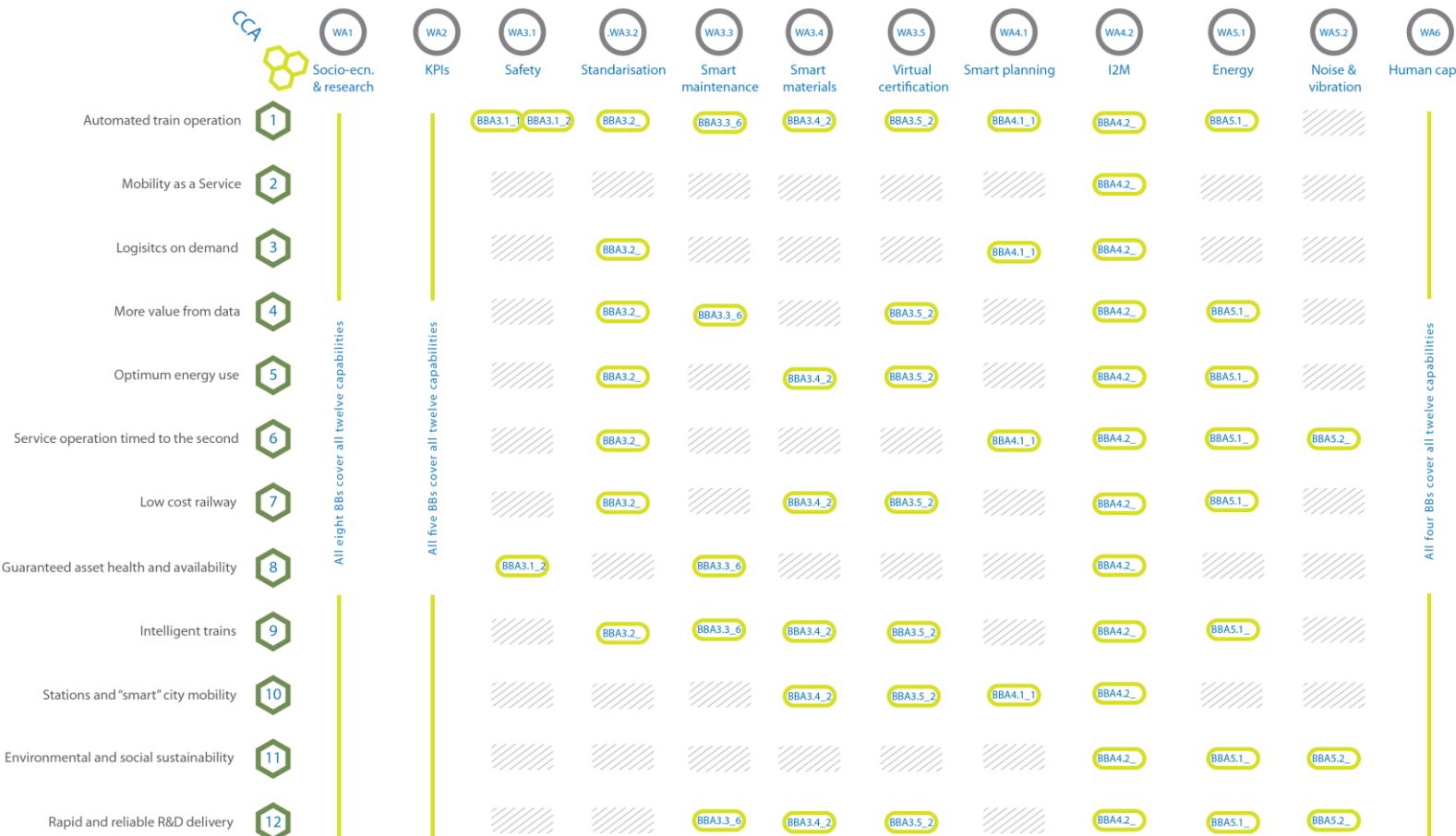


Fig. 20 CCA alignment of building blocks (BBs) with capabilities

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 €400m have already been invested through the H2020 Lighthouse projects and specific S2R ongoing projects. The following diagram (Fig. 21) summarises the status of the R&I program while general details of these on-going projects can be found in Appendix A and online¹⁶

¹⁶ <http://shift2rail.org/projects/>

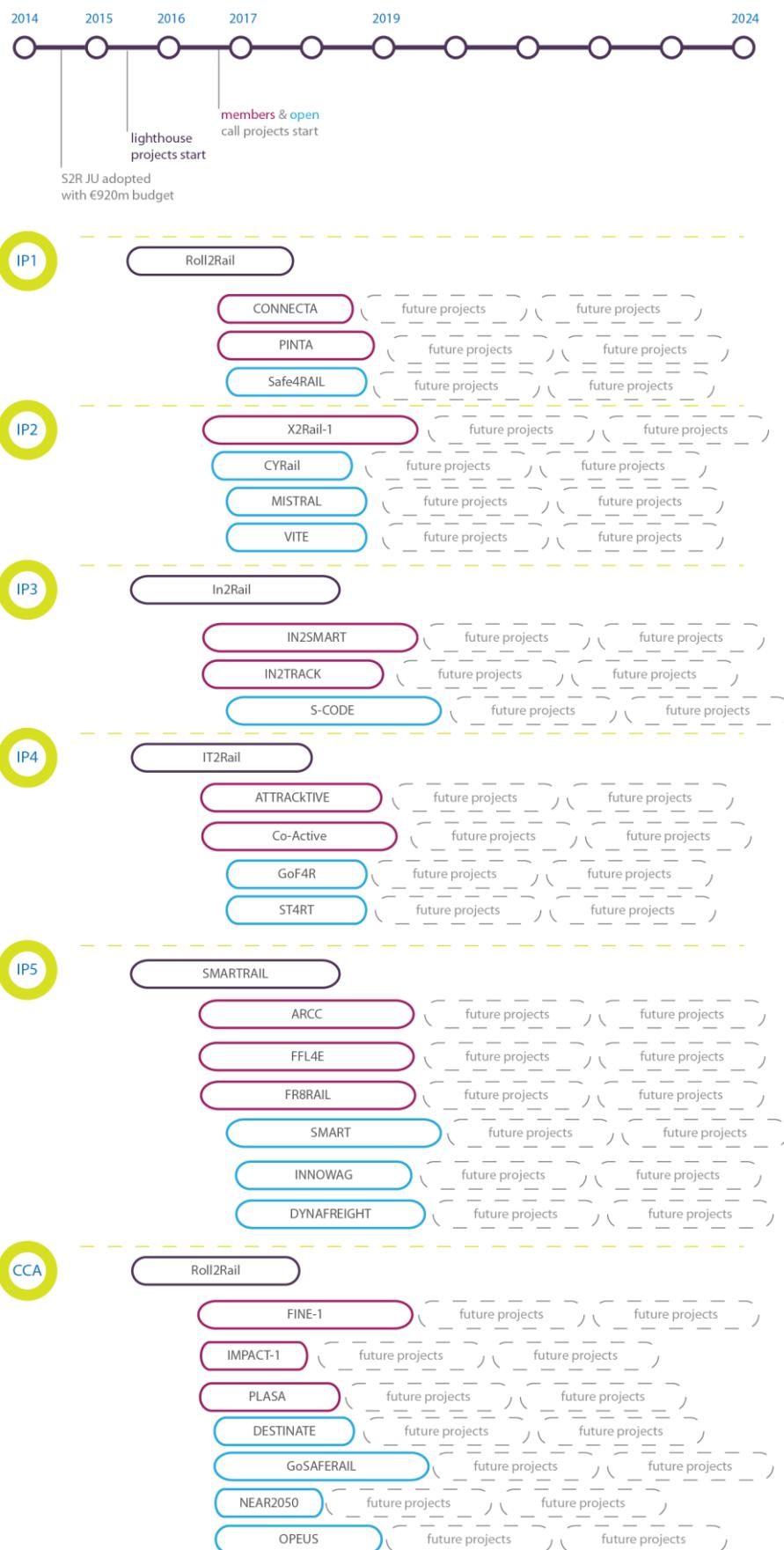


Fig. 19. Overall R&I programme status after first call grants awarded

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 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 assessment¹⁷ 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;

¹⁷ Impact assessment: Proposal for a Council Regulation establishing the Shift2Rail Joint Undertaking SWD(2013) 535 final, Brussels, 16.12.2013

- 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.

Methodology for a societal business case

The Union's resources are limited. Goods and services are scarce resources, time is short, good health and clean environment requires resources. Citizens and businesses needs and wishes, on the other hand, appear to be substantial in many times. Therefore, both society and the individual must always make choices and priorities, how to use the resources best, even when the options have many effects that are uncertain and when price tags are missing. The method used to make socio-economic profitability assessments is 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 corner stone in knowing what is the best measures and projects to meet the societal expectations of the future rail system.

To do this, a systematic approach is necessary. Within CBA the profitability calculation 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 calculation or private finance or government finance aims to calculate the net value of the economic effects that affect an individual company, individual organization or the individual. The socio-economic profitability calculation, on the other hand, aims at calculating the total net worth of all economic effects for all citizens in society.

The CBA has methods for evaluating resources and benefits that are not market-prone, which business economics calculation methodology does not have. In addition, the socio-economic analysis includes effects for all citizens, not just the effects that affect the organization 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, you can make a valuation in money 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 most demanded 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 great as possible, both today and in the future. Socially profitable measures contribute to socio-economic efficiency, provided that we choose all profitable measures 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 counts. 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 shall 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

Standards and standardisation have been highlighted under the Europe 2020 strategy as pivotal in supporting 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 of the subsystems that S2R can address in its different TDs to produce the expected system results, including procedures to implement innovative 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 example, with the interfaces between the on-board train control and monitoring system (TCMS) and the connected train functions such as traction, doors control, brakes etc.

A careful management of the functional interactions of the different layers of the railway system, 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.

Although, 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 in 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, and 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^{18,19} 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;
- It helps to ensure that the project results will be used well beyond the duration of the project;
- It is a powerful tool for bringing research and new technologies to the market;
- Etc.

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

¹⁸ Blind Knut : "*The impact of Standardization and Standards on Innovation*" – Manchester Institute of Innovation Research, February 2013.

¹⁹ CEN-CENELEC "How to link standardization with EU research projects: Advice for CEN and CENELEC Members"



A standard assessment approach is followed for the systematic capture, analysis and mitigation of risks associated with the current Shift2Rail 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 update.

The registry of risks to Shift2Rail is periodically updated by year end. The current version (2016) is included in Table XXXX. Risks are identified according to their relevance, with appropriate mitigation plans described and aiming at reducing or eradicating the potential effects of any given risk.

RISK MANAGEMENT EXERCISE FINALISED BY END OF JUNE

Table 2. Updated Shift2Rail JU risks register

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*"²⁰, the S2R JU is working strictly with European Commission DG MOVE, as well as DG RTD, the European Agency for

²⁰ Article 2(i) of the S2R Statutes annexed to the S2R Regulation.

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*" though different measures of cooperation. In the same manner, the relation 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 to 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 system, 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 the 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 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.).