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Comparison between the ERRAC Strategic Rail Research and Innovation Agenda (SRRIA) and the SHIFT2RAIL Multiannual Action Plan (S2R MAAP)

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Task	5.1	Comparison between the ERRAC SRRIA and the S2R MAAP

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ACRONYMS

ATO: Automatic Train Operation
AWP: Annual Work Plan
CCA: Cross-Cutting Activity
DRIMS: Dynamic Railway Information Management System
ERRAC: European Railway Research Advisory Council
ERTMS: European Railway Traffic Management System
ETCS: European Train Control System
ETP: European Technology Platform
EU: European Union
FP6: Framework Programme 6
FP7: Framework Programme 7
GNSS: Global Navigation Satellite System
H2020: Horizon 2020
ICT: Information and Communication Technology
IP: Innovation programme
IT: Information System
ITD: Integrated Technology Demonstrator
ITS: Intelligent Transport Systems
KPI: Key Performance Indicator
LCC: Life Cycle Cost
MAAP: Multi Annual Action Plan
N&V: Noise & Vibration
PPP: Public-Private Partnerships
RAMS: Reliability, Availability, Maintainability, Safety
RIMMS: Railway Integrated Measuring and Monitoring System
RS: Rolling Stock
RTD: Research Technology Development
RTSE: Rail Technical Strategy Europe
R&D: Research & Development
R&I: Research and Innovation
S2R JU: SHIFT2RAIL Joint Undertaking
SiC: Silicon Carbide
SME: Small and Medium sized Enterprise
SPD: System Platform Demonstrator
SRRA: Strategic Rail Research Agenda
SRRIA: The Strategic Rail Research and Innovation Agenda
STC: Short Training Courses

TAF: Telematic Applications for freight
TCMS: Train Control Management System
TD: Technology Demonstrator
TEN-T: Trans-European transport network
TMS: Traffic Management System
TP: Technology Platform
TRL: Technology Readiness Level
TSI: Technical Specification for Interoperability
UTO: Unattended Train Operation
WA: Work Area
WP: Work Package

EXECUTIVE SUMMARY

The FOSTER RAIL project is addressing the challenge to strengthen and support research and innovation cooperation strategies in the European rail sector. The project's work plan aims to enhance coordination among main stakeholders and actors in the European rail sector and rail industries and to integrate the work done so far by ERRAC and its working groups. Starting with the already published ERRAC-ROADMAP, the FOSTER RAIL project has continued to coordinate the research and innovation agenda and priority setting process among the wide range of relevant stakeholders in the rail sector while enhancing also the coordination and cooperation with the other surface transport stakeholders. FOSTER-RAIL has among others already delivered a Rail Business Scenario as basis for the newly developed new Strategic Rail Research and Innovation Agenda (SRRIA) and specific Rail Technology & Innovation Roadmaps aimed at 2050. The output will among others be used to advise the European Commission, Shift2Rail and other research programmes on their content. This Deliverable compares this SRRIA with the Multi Annual Action Plan produced by the Shift2Rail JU as serves to analyse important areas in rail research yet to be covered.

Overall Research and Innovation activity in the rail transport sector can contribute, through the development of ground-breaking solutions, to most of the objectives and challenges rising from an expected growth by 2050 of rail freight volumes by more than 80% and number of rail passengers by more than 50% in Europe. Research and Innovation are also of key interest for the rail supplier industry to keep its world leading position in a more and more competitive market.

Increasing the attractiveness of a high capacity, environmentally friendly and cost efficient railway in Europe will underpin economic growth and societal development. **Preserving the leading position of the European supplier industry will maintain a large manufacturing industry in Europe important for its economy.**

Since its creation in 2001, **ERRAC, the European Railway Research Advisory Council** has been directly involved in the elaboration of the relevant transport-related research activities of FP6, FP7 and H2020 providing crucial guidance on research and development priorities in the rail transport sector. **ERRAC** involves all types of railway stakeholders in defining the research and innovation strategy of the rail sector in Europe, supporting and enhancing co-operation among European manufacturers, supply industry and academia as well as creating links with decision-makers (at European, national and regional levels) and other sector stakeholders.

The **updated Strategic Rail Research and Innovation Agenda (SRRIA 2014) worked out by ERRAC**, constitutes a step change in research and innovation and aims at orienting and guiding the research efforts of the railway sector and the decisions of policy makers and other stakeholders. **SRRIA 2014** sets out research and innovation priorities structured on a long-term basis around **three sets of** domains. The **first** addresses the attractiveness of rail and public transport and the future increasing demand for mobility of persons and goods. The **second, in a whole system approach,** includes three critical areas within a sector-wide framework and finally, the **third** set covers five well-established asset-related areas. For each of these three sets, important challenges are identified on their own and even more, together they address the most serious requirements for the development of the rail

transport mode and for maintaining and strengthening the leading role of the European rail manufacturing industry on the global increasingly competitive market, namely:

- A higher quality of service, a reduced cost of railway operations, a higher capacity of the infrastructure to increase the competitiveness of the railway of transport;
- Overcoming the fragmentation of rail market, a legacy of the historical national approach;
- Higher competitiveness and knowledge of the European supplier industry through the Innovation challenge to retain its world leadership.

The main objective of the 10 ERRAC FOSTER RAIL roadmaps, is to sustain an ambitious way forward to fully develop the railway sector in Europe for the decades to come, for the rail supplier industry to make it sustainably competitive compared to the Asian one and, for the European citizen, to improve overall transport efficiency in Europe.

These overarching goals will necessarily imply the emergence of innovative approaches in business models, services and products, throughout the whole rail value chain. **This will, in turn, require a significant increase in research and innovation efforts.**

To improve the efficiency of EU funding in order to better address societal challenges and to keep supporting the world leadership position of the supplier industry by pooling together with existing R&I efforts and expertise, namely through Public-Private Partnerships (PPPs) in the form of Joint Undertakings, the SHIFT2RAIL Joint Undertaking (S2R JU) was established by Council Regulation (EU) No 642/2014 of 16 June 2014. **The S2R JU is a public-private partnership, providing a platform for the main actors of the European rail system to invest and work together with a view to driving innovation in the years to come by implementing a comprehensive and coordinated research and innovation strategy.**

S2R JU has established **a Strategic Master Plan** and will ensure its effective and efficient implementation. Thus, in order to manage research works, the S2R JU has worked out a Multi Annual Action Plan - MAAP, to translate the S2R Master Plan into Technology driven research with the delivery of validated prototypes during the next 7 years.

The aim of the S2R MAAP is to ensure not only that each Annual Work Plan (AWP) is anchored in a long-term approach that guarantees the success of the investment, but also to provide the basis for the long-term cooperation between all members of the S2R JU and other participants beyond the current S2R.

The present document (D5.8) is aimed to provide a comparative assessment between the ERRAC SRRIA and the S2R MAAP, in terms of strategic objectives, roadmaps and annual work plans, type and structure of research. For each theme covered in the IPs (the 5 Innovation Programmes and the CCA of S2R), a detailed analysis of the SRRIA and the MAAP is carried out by looking, in a comparative manner, within the major thematic areas. Then, an appraisal is made to analyse, **first,** how well these two documents compare and align with each other and **second**, to identify the differences as the SRRIA is on a longer term perspective than the S2R/MAAP that has the limited life span of the H2020 Program.

For each IP, additionally, an analysis is carried out to jointly appraise a recent comparison exercise done by UIC, concerning the different enablers identified by RTSE and the topics/themes covered in the MAAP.

Finally, conclusions are drawn in the last chapter highlighting the specific topics/domains that need additional H2020 funding to fulfil the longer term perspective of the SRRIA.

1 RAIL RESEARCH STRATEGIC OBJECTIVES

Rail is becoming a knowledge-intensive, fast-incorporating new technologies and an internationally increasingly competitive sector, striving to create an optimal ecosystem for innovation. It pulls together (from across the European continent) excellent research institutions and a world leading manufacturing industry, with a strong and increasing research, development and innovation (R&D&I) investment.

ERRAC was set up in 2001 with the ambitious goal to contribute to the revitalization of the European Rail Sector through the creation of the Single European Railway Area to better serve the European citizen, to improve the internal market in all rail segments, and to increase the competitiveness of the supply industry, by guiding and fostering research and innovation efforts at the European level.

Within ERRAC, all major rail stakeholders are working together, comprising 45 representatives from each of the major European rail research stakeholders: manufacturers, mainline and urban rail operators, infrastructure managers, the European Commission, EU Member States, academics and users' groups.

ERRAC covers all segments of rail transport: from conventional to high-speed and freight applications to urban and regional services.

ERRAC is mainly driven by the European policy framework for rail and embedded in the European framework programme for research and the European Competitiveness Strategy[3].

The European policy for rail is currently targeting the implementation of the 4th Railway Package, and to contribute reaching the objectives of the 2030 Climate and Energy Policy Framework under an agreement with the European Council on 23 October 2014.

With the launching of the S2R JU in July 2014, a major milestone has been reached for ERRAC. S2R is the first large-scale European research initiative for rail. S2R will be the focal point for European rail research in the coming years, but it is a time-limited Program aiming at delivering validated solutions to be implemented in the 2020s. This is short term in a RD&I agenda. **Consequently, there is a need to carry out complementary developments as well as to invest in exploring additional ones beyond the S2R time scale.**

Within FP7, the project FOSTER-RAIL is part of a set of Level 1 Coordination and Support Actions (CSAs) supporting the land transport European Technology Platforms activities.

Several milestone documents are brought in as references and with relevant guidelines providing directions specifically addressing the European efforts required for research and innovation to achieve the ambitious goal set out by the European Commission in the Transport White Paper published in 2011 where it is recognised that European transport is at a crossroad, and that old challenges are still pending whereas new ones have emerged.

The European Union's framework programme for research and innovation "HORIZON 2020", launched in December 2013, includes the above mentioned flagship initiative for rail research, the SHIFT2RAIL Joint Undertaking. It is the first Public Private Partnership (PPP) in rail research to seek focused research, innovation and market driven solutions by

[3] https://books.google.pt/books?hl=en&lr=&id=DoxNHWr2-ncC&oi=fnd&pg=PR6&dq=european+competitiveness+strategy&ots=B7_34AcMa0&sig=ogvKLY418JYNRhtpwTGiNGNOf_I&redir_esc=y#v=onepage&q=european%20competitiveness%20strategy&f=false

accelerating the integration of new and advanced technologies into innovative rail product and services, thus responding to the current mobility challenges. ERRAC reaffirms Europe's need to offer a well-balanced, business-led and strong programme of research and innovation for the railway system over the next decades.

2 TRANSPORT WHITE PAPER

The European Union is committed to a "Europe2020" strategy based on smart, sustainable and inclusive growth taking into account the environmental security, social and economic implications of current patterns of energy use. Ways to decouple economic growth from resource and energy use have to be found. Thus, a shift to a resource-efficient, low carbon, growth economy, avoiding transport pollution and road congestion is of a paramount importance. Achieving those targets calls for a massive technological improvement and a radical systemic change. Rail is seen as being an important part of the solution. Among the high level goals for a competitive and resource-efficient transport system (Section 2.5 of the White Paper[4]), ten of them imply significant development of rail infrastructure, services and technologies:

Developing and deploying new and sustainable fuels and propulsion systems

1. Halve the use of 'conventionally-fuelled' cars in urban transport by 2030; phase them out in cities by 2050 and achieve essentially CO2-free city logistics in major urban centres by 2030. This cannot be achieved without increasing the capacity of the existing rail infrastructure, through a major investment in public transport and the development of new solutions.

Optimising the performance of multimodal logistic chains, including by making greater use of more energy-efficient modes

2. 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, facilitated by existing efficient and green freight corridors. To meet this goal will not only require appropriate infrastructure to be financed but also the emergence of news solutions.
3. By 2050, complete a European high-speed rail network, i.e. triple the length of the existing high-speed rail network by 2030 and maintain a dense railway network in all Member States. By 2050 the majority of medium-distance passenger transport should go by rail. This cannot only be achieved through major infrastructure investment but, more critical, by offering a very attractive rail way of transport so that it becomes the traveller first choice.
4. A fully functional and EU-wide multimodal TEN-T "core network" by 2030, with a high quality and capacity network by 2050 and a corresponding set of information services.
5. By 2050, connect all core network airports to the rail network, preferably high-speed; ensure that all core seaports are sufficiently connected to the rail freight and, where possible, inland waterway system.

[4] Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system: http ://eur-lex.europa.eu/LexUriServ/LexUriServ.do ?uri=COM :201 :0144 :FIN :EN :PDF

6. […] Deployment of [air traffic] equivalent land and waterborne transport management systems (ERTMS4, ITS5).
7. […]. Deployment of the European Global Navigation Satellite System (Galileo). The railway has been and is continuing to explore the use of GNSS for traffic management to increase infrastructure capacity.
8. By 2020, establish the framework for a European multimodal transport information, management and payment system.
9. By 2050, move close to zero fatalities in road transport. In line with this goal, the EU aims at halving road casualties by 2020. The shift from road transport to rail transport will definitely contribute. Make sure that the EU is a world leader in safety and security of transport in all modes of transport.
10. Move towards full application of "user pays" and "polluter pays" principles and private sector engagement to eliminate distortions, including harmful subsidies, generate revenues and ensure financing for future transport

3 ERRAC RAIL ROUTE 2050

An initial update of the ERRAC vision for the future of rail, projecting it to 2050, is provided in Rail Route 2050[5], addressing the European effort required for research and innovation to achieve a common ambition. This requires streamlined investment from frontier, applied/focused research, development and demonstration/validation to real market uptake, supported by both investments as well as by aligned complementary legislation.

There is an urgent need for action to increase the capacity of railway network that can then help enable effective modal shift towards rail, which has such potential to support a low carbon economy. Railway transportation will also need to develop its attractiveness and competitiveness to meet that potential. Railways will have to be radically improved in order to remove the barriers to the emergence of a truly-competitive rail transport offer based on the following evidences/facts:

- Rail Transport between European Metropolitan Centres offers Competitive Transport Connections;
- Rail Transport is the suitable solution for Urban Mobility;
- Technology Adds Value to the Rail Market;
- Limited public funding, namely limited investment in railway infrastructure.

4 SRRIA, A SYSTEMIC AND LONG TERM VISION

Building on the 2007 Strategic Rail Research Agenda[6] (SRRA) and following the publication of "RAILROUTE 2050", this updated Strategic Rail Research and Innovation Agenda, a step change in research and innovation, SRRIA[7] aims at orienting and guiding the research effort of the railway sector and the decisions of policy makers and other stakeholders.

[5] http://www.errac.org/wp-content/uploads/2013/11/D9-SRRA-RAILROUTE2050.pdf

[6] http://demo.oxalis.be/errac/errac_website/wp-content/uploads/2013/06/SRRA-2007.pdf

[7] http://www.errac.org/wp-content/uploads/2014/11/CER_FosterRailReport.pdf

SRRIA sets out research and innovation priorities structured around three thrusts of themes. The first addresses the attractiveness of rail and public transport and the future demand that the rail sector aims to meet. The second set includes three critical themes within a sector-wide framework to meet the future transport demand and finally the third set covers five well-established rail asset-related themes. This thematic arrangement can be briefly described as follows:

Attractiveness of rail and public transport

- Customer experience
- Strategy and economics

A whole system approach

- Capacity, performance and competitiveness
- Energy and Environment
- Safety (including certification) and security

Assets

- Control, command, communication and signalling
- Infrastructure
- Rolling stock
- IT and other enabling technologies
- Training and education

A SYSTEM APPROACH

Rail is a service business oriented system which must be designed, constructed, operated and maintained holistically, taking into account the important interfaces between its constituent parts, some of which are safety critical, and upon which the integrity of the system depends. No part of the rail system should therefore be developed without considering the interaction with the other parts of the system.

Rail subsystems developed for a given rail market segment will only be effective if each is understood and managed taking account of the whole system, with particular attention to the interfaces between the different subsystems.

This holistic approach is also needed to address environmental issues (e.g. noise, vibration and energy); achieve resource-efficient technologies; to fully benefit from innovation; and reduce whole life cycle costs. The sector's costs can also be reduced by faster, transparent and efficient (such as virtualisation) authorisation and certification processes to reduce time between manufacturing of a new train and its operational exploitation. They should be undertaken in an economic manner and harmonised across the EU member states.

BASIC RESEARCH IN LOW TRLs (Technical Readiness Levels)

ERRAC endorses the challenges identified in the SRRIA and the objectives outlined in the S2R Master Plan. In particular, ERRAC supports the demand for a step increase in reliability and punctuality, and considers this to be achievable with at least 97% system reliability, as other

industries have achieved. In each domain, the corresponding part roadmap outlines the level and topics associated with longer-term research.

As an essential condition to ensure step changes and paradigm shifts, the different parts as well as other transport modes roadmaps identify a range of low TRL R&D activities on:

- basic research topics for longer-term developments linked to fundamental principles and emerging technologies;
- cross cutting themes aiming to understand the way in which long term trends in society and technology will influence mobility patterns;
- better appraising of the costs and benefits of alternative innovations.

This effort will benefit from a special support from S2R and the SRRIA visionary roadmaps, to ensure a proper alignment of present S2R objectives with a coherent long-term ERRAC vision for the railway sector. Those roadmaps have been updated within the ERRAC FOSTERAIL Project. This leads to the identification of H2020 additional support to properly cover the planned development of the SRRIA roadmaps.

5 RATIONALES OF THE SRRIA AND THE MAAP

This chapter is appraising in a comparative manner the nature and main features of the ERRAC SRRIA and the S2R MAAP by looking at the level of alignment of medium and long term objectives and visions and the way the railway community intends to be involved.

5.1 SRRIA. Long term visions with the corresponding technology roadmaps

Passengers enjoy seamless multimodal journeys that cost less and are easy to plan, select, book and modify. They experience a comfortable, safe and secure environment and enjoy the availability of real-time traffic and whole-journey information about journey options should problems arise with modal connections or degraded operating conditions.

Business analytics within strategic economics domain facilitate more customer driven services. Data collection and improved and harmonized statistics feed convincing economic studies and traffic forecasts and the development of customer-oriented business models. Significant improvements in operational reliability, more affordable cost of rail travel and appreciation of the security of the railway system contribute to the overall attractiveness.

From a technological perspective, innovation has produced highly energy and resource efficient systems for rolling stock and infrastructure and control, command, signaling and communication systems.

Quality, safety and security management systems are harmonized across Europe to achieve an interoperable European wide rail system by that time.

Major innovation trends in the rail sector are based on the integration of new technologies: the rail transport has fully integrated the digitalization revolution for operational and maintenance purposes, offering to, e.g. thanks to analog components converging with digital and ultrasound technologies allowing high speed track flaw detection and rail users the expected fully functional digital communication and information transmission during their journey.

High-speed rail promotes lifestyles in which long distance commuting on a daily, weekend or some days per week frequency becomes increasingly common and affordable.

The rail mean of transport has not only retained but developed its share of transport, not only in the dense and urbanized metropolitan regions but also for intercity connections using many of the same principles and methods as for urban rail systems despite the development and implementation of semi-and fully-autonomous and/or energy-alternatively-propelled road car systems.

Rail research and European innovation policies increasingly target a shift to rail strategy with more restrictions on road transport and the phasing out of conventionally fuelled vehicles in urban areas.

5.2 Involvement of all the chain value of rail community and National TPs

The development of an EU-wide rail research strategy is challenging, as it encompasses a large scope of aspects and stakeholders of different nature. These cover the major stakeholders i.e. rail supplier industry, railway undertakings, infrastructure managers, academia and end users and for certain aspects the European, national, regional and local transport authorities. Numerous parties from other transport modes which modal share is higher than in rail and which compete with rail are also considered.

With a view to realise the objectives of the Europe 2020 Strategy and further on the vision of the White Paper 2011 for a competitive and resource-efficient future transport system, it is essential to establish the proper links and cooperation between ERRAC constituents and other relevant transport related stakeholders. In this regard, the SRRIA also covers the **acquisition of new knowledge in advanced technological areas** and in low TRL research. The FOSTERAIL WP1[8] has addressed this mission with an emphasis in cooperation with other surface transport European Technology Platforms (ERTRAC, WATERBORNE and ALICE), rail-related National Technology Platforms (NTPs), the European Commission, decision makers and relevant transport and railway authorities both at European and Member-State level (and even at local – city – level).

6 SHIFT2RAIL: A BUSINESS-ORIENTED APPROACH DELIVERING TRL 7 RESEARCH (E.G. PROTOTYPES) BY THE NEXT DECADE

A key objective of H2020 is to improve the efficiency of EU funding and better address societal challenges by pooling together existing R&I efforts and expertise, namely through Public-Private Partnerships (PPPs) in the form of Joint Undertakings. In line with this, the S2R JU was established by Council Regulation (EU) No. 642/2014 of 16 June 2014 as a public-private partnership in the rail sector with a view to managing and coordinating all rail-focused research and innovation activities funded under Horizon 2020. Cross-industry coordination of the design and development of subsystems and components reduces duplication and minimises negative cross-system impacts.

[8] FOSTERAIL PROJECT, Deliverable D1.1 Clustering Multi-modal Research and Innovation Issues with Other ETPs, and Deliverable D1.4, Developing Links and Coordination Strategies between ERRAC, EU and National Technologies Platforms. Recommendations for the Future

In practice, S2R JU will foster the introduction to the market of a new generation of high-quality reliable rolling stock, combined with intelligent advanced traffic management and control systems, new railway infrastructure sub-systems, and innovative IT solutions and services, that will radically improve capacity and performance of the railway systems for the various rail market segments and facilitate cross-border railway operations throughout various Member States, while substantially reducing the life-cycle cost of rail services.

For the EU passenger, this will mean more affordable and better accessible travel, more travel options, more comfort, and improved punctuality. For the freight forwarder/shippers, the rail freight will become more cost effective, punctual, and traceable and will become the preferred shipment option. For rail in general, this will mean more users and, thus, a step closer towards the paradigm of the modal shift to rail. Importantly, European companies, thereby increasing their competitiveness on the global marketplace, will develop this challenging program.

7 SHIFT2RAIL Multiannual Action Plan - MAAP[9]

7.1 The S2R Master Plan[10]. Historic background

The S2R Master Plan[11], the key strategic document structured around the five 'Innovation Programmes' ('IPs') thematic areas, that lead to the adoption of the first S2R MAAP – Multi-Annula Action Plan. The MAAP translates the S2R Master Plan into concrete actions, milestones and deliverables to be undertaken and produced during the lifetime of the S2R JU.

The SHIFT2RAIL Founding Members of the Joint Undertaking are the European Union and eight major rail stakeholders, including rail equipment manufacturers (Alstom, Ansaldo STS, Bombardier, Construcciones y Auxiliar de Ferrocarriles (CAF), Siemens and Thales), as well as 2 infrastructure managers Network Rail and Trafikverket. Following a selection process, several Associated Members have been selected: AERFITEC, Amadeus IT Group SA, AZD Praha s.r.o, CFW Consortium, Deutsche Bahn AG, DIGINEXT, Faiveley Transport, HaCon Ingenieurgesellschaft mbH, INDRA SISTEMAS S.A., Kapsch CarrierCom AG, Knorr-Bremse GmbH, MER MEC S.p.A, Patentes Talgo S.L., Smart DeMain (SDM) consortium, Société Nationale des Chemins de Fer Français Mobilités (SNCF Mobilités), SmartRaCon consortium, Swi'TRACK'EN consortium, Virtual Vehicle Austria consortium+ (VVAC+).

7.1.1 Proper alignment of S2R Multiannual Action Plan - MAAP objectives with the long term vision of ERRAC

The Strategic Research Agenda is the key deliverable of a European Technology Platform. It sets out research and technological development priorities for the medium to long term, including measures for enhancing networking and clustering of the RTD capacity and resources in Europe.

[9] http://www.shift2rail.org/wp-content/uploads/2013/07/MAAP-final_final.pdf

[10] http://ec.europa.eu/transport/modes/rail/doc/2015-03-31-decisionn4-2015-adoption-s2r-masterplan.pdf

[11] The document was first approved by the Governing Board of the S2R JU on 24 September 2014 and consequently endorsed by the Council on 10 February 2015 and is available at: http://ec.europa.eu/transport/modes/rail/shift2rail_en.htm

The development of the SRRIA -Strategic Rail Research and Innovation Agenda was coordinated by FOSTER RAIL working groups, endorsed by the ERRAC Steering Committee that included **representation from a large range of stakeholders**. The active involvement of Member States was channeled through the FOSTER RAIL WP1 to reflect their views, through specialized working groups within ERRAC and their associated organizations at national level.

In parallel with the definition of its Strategic Rail Research and Innovation Agenda, ERRAC began to specify a **deployment strategy** including **the different roadmaps** at this stage. The deployment strategy anticipates the key elements required in order to implement the SRRIA effectively with the aim of bridging the gap between the current state of development of a given technology and its eventual deployment, namely:

- **Focused research and innovation** (R&I) and market-driven solutions by accelerating the integration of new and advanced technologies into innovative rail product solutions.
- Promotion of the competitiveness of the European rail industry and addressing changing and/or solving EU transport needs.
- Development of the necessary technologies to try and fulfil the needs of most rail market segments.
- A system approach to the specification of the needs with the establishment of "Requirements and Implementation groups" involving the rail stakeholders.
- Step-change efforts and development of prototypes.
- Integration and demonstration at system level through "System Platform Demonstrations" around well-identified market segments.
- Involvement of forward-looking market actors ready to invest in innovation and a commitment to inclusiveness ensuring a wide participation of major actors at European level.
- Enabling the implementation of a certain number of priorities of the Strategic Rail Research and Innovation Agenda.

7.1.2 Technology driven research with delivery of prototypes

The demonstration of technical achievements, up to TRL 7, will be based on the three-fold architecture presented in Figure 1 below: technology demonstrators (**TDs**), integrated technology demonstrators (**ITDs**) and system platform demonstrators (**SPDs**).

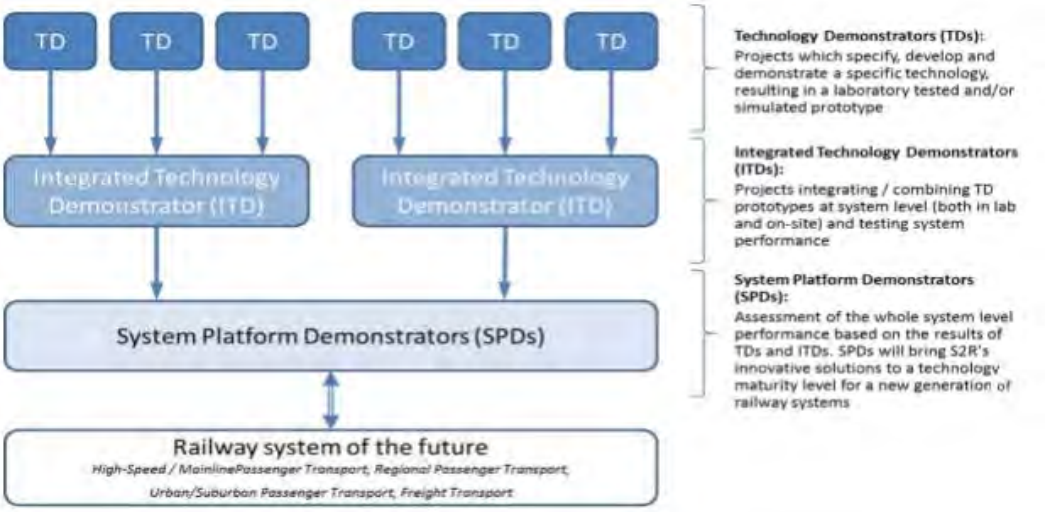

Figure 1 – Structure of demonstrators within SHIFT2RAIL

The establishment of the S2R JU has enabled railway stakeholders to further build relationships between them and develop strategic partnerships in a sector that has traditionally been overly segmented. This collaborative approach consists on the R&D development, testing, and validation of demonstrations in real or simulated operational scenarios. This will ensure that the products developed by S2R JU are in line with the business and customer needs in the rail sector, and that they can be introduced to the market in a reliable way from the first day of entry into service, thereby contributing to enhanced reliability and quality of services in both the passenger and freight rail segments, and to the cost reduction.

The financial commitment of the S2R Joint Undertaking other than the Union is earmarked at 470 M€ demonstrating the private members' commitment in accelerating **the generation of new knowledge**, innovation and the uptake of research into strategic technologies and products, leading to enhanced productivity and strengthened industrial competitiveness.

8 MANAGING RESEARCH AND DEVELOPMENT

8.1 ERRAC SRRIA rational

ERRAC is committed to a long-term framework fostering the innovation process and to achieve its ambitions to contribute to the rail business success, namely:

1. Support the long-term vision, strategic objectives and the innovation agenda;
2. Update and improve the research and innovation roadmaps by defining research priorities, milestones for technology breakthroughs leading the research agenda in specific thematic areas;
3. Identify business prospects and promote market uptake: ensuring real/proper market uptake of the technology, operations, services, and business models developed in the different EU funded projects by understanding the main features of final application;

4. Identify the customer, the surrounding conditions for the business implementation and the mechanisms to close the gap between the end of project and market readiness;
5. Provide information on the range of funding sources and of potential new resources for funding transport R&I.

8.2 SHIFT2RAIL Multi Annual Action Plan – MAAP rational

A key objective of H2020 is to improve the efficiency of EU funding and better address societal challenges by pooling together existing R&I efforts and expertise, namely through Public-Private Partnerships (PPPs) in the form of Joint Undertakings. The main tasks of the S2R JU are:

1. To develop, integrate, demonstrate, and validate innovative railway technologies and solutions with the objective to improve the competitiveness and attractiveness of the European Railway Sector on the world business market and as an efficient European way of transport;
2. The performance of the railway system will only be improved if it is understood and managed as a whole system, shared between all actors, with particular attention to the interactions between the parts of the system managed by the different actors;
3. S2R is the first European rail Joint Undertaking to seek focused research and innovation (R&I) and market-driven solutions by accelerating the integration of new and advanced technologies;
4. Strategic partnerships in a collaborative approach will consist on the R&D development, testing, and validation of demonstrations in real or simulated operational scenarios.

8.3 Development of the Multi Annual Action Plan (MAAP)

The MAAP **is a "second layer" of the Master Plan and it is intended to provide a detailed, long-term investment plan that allows for continuity and synchronicity (cf. Art. 2 Statutes)**. It identifies concrete actions, milestones and deliverables to be undertaken and produced by the S2R Projects (including open calls) from 2015-2024. That document **provides a degree of certainty as to the projects that will be carried out by the JU and by which members, or through open calls, to create consistency and unity among the technical proposals of all members. The MAAP ensures that all members of the S2R JU commit to cooperate to implement common projects.**

The MAAP will serve as the main reference point for the future Annual Work Plans of the JU. It already made the link with the Annual Work Plans for 2015 and 2016 and shall serve as the main reference point for subsequent ones. The MAAP will serve also as a key reference for the evaluation of proposals submitted in response to calls for proposals launched by the S2R JU and it will be regularly updated to take into account project results.

The MAAP has been **developed by the experts involved in the S2R Joint Undertaking on the basis of the Master Plan, the scoping paper for the draft MAAP, and the technical proposals of the candidate associated members, as well as then results of their respective evaluations.**

The MAAP should treat the entire work programme as an integrated system framework as shown in Figure 2. The MAAP should have a total value of 773 M€, including the so-called S2R lighthouse projects (H2020 Projects funded before the operational set up of the S2R JU). It shall foresee a minimum of 131 M€ for open calls. Open calls shall include fundamental research that is not necessarily directly related to the technical activities in the IPs given that there is no Union budget for rail-focused research outside of S2R. During the period in which the bilateral membership negotiations and the multilateral MAAP development processes run in parallel, the provisional MAAP may have an overall value that is higher than its final value. The MAAP will be updated to reflect decisions on budget allocation for individual members as determined in the bilateral negotiations, ensuring integration and that there are no duplications or overlaps.

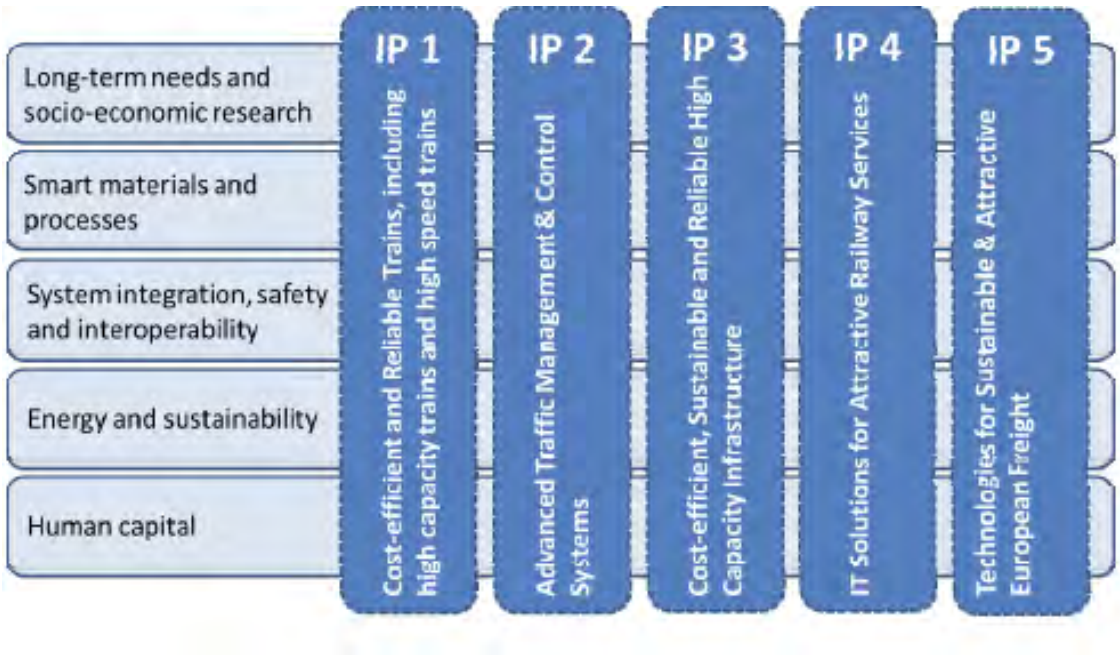

Figure 2: Shift2Rail systems approach and cross-cutting themes

A sustainable growth of the rail sector requires a dedicated and balanced approach addressing specific common research and innovation challenges, while integrating and demonstrating cooperation between stakeholders across the whole rail value chain for the different market segments.

Responding to these challenges will require different types of activities, including:

- Other supporting and demonstrator activities;
- Research and technological development activities;
- Demonstration activities.

8.3.1 System platform demonstrator (SPD)

Ultimately, SHIFT2RAIL will carry out proof of rail systems, design and functions on fully representative innovative railway configurations in an integrated environment and close to real operational conditions. To simulate and test the interaction and impact of the various

systems in the different rail market segments, demonstration platforms are proposed covering high-speed passenger rail, regional passenger rail, urban/suburban passenger rail and rail freight. The choice of demonstration platforms is geared to the most promising and appropriate market opportunities to ensure the best and most rapid exploitation of the results of SHIFT2RAIL.

8.3.2 Integrated Technology Demonstrators (ITDs)

The ITDs will allow for the testing of combinations of components and sub-systems already verified and validated within the Technology Demonstrators within virtual or physical railway environments for demonstrating the innovation potential of the components in different sub-systems and systems, taking into account functional and operational specifications and the technical interfaces among the various TDs.

ITDs will also enable the analysis of compliance with the regulatory requirements and will be followed up with a controlled approach to future certification work.

8.3.3 Technology Demonstrators (TDs)

Technology Demonstrators will focus on the development or adoption of **innovative technologies and models within the rail sub-systems identified in the Innovation Programmes**. They will seek inspiration from innovative technologies, materials and methods used or explored in other sectors. The innovations developed may consist of software and/or hardware systems.

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

8.3.4 Demonstration activities[12]

An important focus of SHIFT2RAIL will be on demonstration activities, which are needed to deliver a quantified impact, but also to provide guidance on the most efficient combinations of these technologies, and assess the potential for improvement to the national, EU transport network and SERA. As a result, demonstration projects will mainly contain activities corresponding to Technology Readiness Level (TRL) levels 4 to 7 (i.e. from technology development in lab to system prototype demonstration in operational environment).

The first commercial units, beyond S2R support, will be designed, with guaranteed performance based on the outcome of the demonstration activities. The scale / maturity of demonstrators should be TRL7. See TRLs definitions in the footnote.

[12] The followingdescriptions apply: TRL 1 – basic principles observed; TRL 2 – technology concept formulated; TRL 3 – experimental proof of concept; TRL 4 – technology validated in lab; TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies); TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies); TRL 7 – system prototype demonstration in operational environment; TRL 8 – system complete and qualified; TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

8.3.5 The role the CCA Structure in Master Plan

Detailed information on how each work area and sub-work area will address the objectives set in the Master Plan is described in Table 54 of the S2R MAAP.

The S2R Master Plan identifies five cross-cutting themes, as shown in table 1, that are of particular relevance to each of the different sub-systems and takes into account the interactions between these sub-systems:

- Long-term needs and socio-economic research
- Smart materials and processes
- System integration, safety and interoperability
- Energy and sustainability
- Human capital

Additionally, to these five work areas, the CCA will also cover the development of a common methodology for assessing the progress and achievement of the SHIFT2RAIL objectives (KPI – Key Performance Indicators - work area).

KPI development embodies a systematic approach to the understanding of the complex interrelations in railways, which will also be useful to forecast a project's costs and benefits.

The deployment of the KPI tool for monitoring the IPs' and TDs' progress, enables continuous reporting and evaluation of the TDs' progress, their influence on the Shift2Rail goals and, if necessary, prioritisation of activities of which a few important ones are highlighted: and confronted with well identified SRRIA topics in the horizontal themes

Table 1– CCA work content and relation to Master Plan

SRRIA	MAAP
• Passenger experience • Customer Orientated Business • Customer Attraction and Customer access • Infrastructure Availability, Capacity and Capability • Infrastructure Exploitation • Passenger trains and Freight Wagons • Integrated Information • Freight Competitiveness • Affordable Travel	• Line capacity increase • Operational reliability increase • Railway system life cycle cost reduction • Enhanced Interoperability • Safety, Standardisation • Smart Maintenance, Smart Materials & Virtual certification

9 COMPARISON BETWEEN SRRIA AND MAAP

As the SRRIA is a document providing a longer term and more comprehensive vision compared to the S2R MAAP, that has to deliver tangible results (physical and virtual prototypes validated, for some of them in real operating conditions) during the coming years on a certain number of sub-systems/components, the comparison has been made starting from the SRRIA.

The SRRIA is structured in two classes of themes. The first class with two sets of themes, of an horizontal nature, addresses the attractiveness of rail and public transport and the future demand that the rail sector aims to meet and deals also with critical themes within a sector-wide framework such as performance energy and environment and safety. The second class covers five well-established asset-related themes.

The work structured within S2R will be developed around five asset-specific innovation Programmes (IPs), covering all the different structural (technical) and functional (process) sub-systems of the rail system, namely:

- IP1: Cost-efficient and Reliable Trains, including high capacity trains and high speed trains;
- IP2: Advanced Traffic Management & Control Systems;
- IP3: Cost-efficient, Sustainable and Reliable High Capacity Infrastructure;
- IP4: IT Solutions for Attractive Railway Services;
- IP5: Technologies for Sustainable & Attractive European Freight.

Figure 3 shows schematically the structural differences between the SRRIA and the MAAP.

For comparison purposes, it was decided to jointly appraise the part roadmap of Training Education with Human Capital issues, the Energy and Environment and the CCA with most of the themes with a strong horizontal nature in the SRRIA.

SRRIA	MAAP
Attractiveness of rail and public transport Customer experience Strategy and economics **A whole system approach** Capacity, performance and competitiveness Energy and environment Safety (including certification) and security	**Cross Cutting Activities** Long-term needs and socio-economic research KPI method development and integrated assessment Safety, Standardisation, Smart Maintenance, Smart Materials & Virtual certification Smart Mobility Energy and Sustainability
Assets Training and education Control, command, communication and signalling Infrastructure Rolling stock IT and other enabling technologies	Human Capital **Innovation Programs** IP1 - Cost-efficient and Reliable Trains, including high capacity trains and high speed trains IP2 - Advance Traffic Management & Control Systems IP3 - Cost-efficient, Sustainable and Reliable High Capacity Infrastructure IP4 - IT Solutions for Attractive Railway Services IP5 - Technologies for Sustainable & Attractive European Freight

Figure 3 – Comparison of the SRRIA and the MAAP structures

Consequently, there is not a one-to-one correspondence between SSRIA and S2R MAAP.

For each R&D topic of the SRRIA a colour code has been given:

GREEN means well covered by the MAAP.
BLUE partly covered and
RED not covered.

For each IP, additionally, an analysis was carried out to jointly appraise a recent comparison exercise done by UIC, concerning the different enablers identified by RTSE and the topics/themes covered in the MAAP[13].

[13] UIC – Rail Technical Strategy Europe, 2016

Very few urban rail operators are members of the Shift2Rail Joint Undertaking despite the call for Associated Members that was extending the partnership of Shift2Rail beyond the Founding Members. Nevertheless, the S2R Strategic Master Plan published on 31 March 2015 considers urban rail as a Shift2Rail System Platform Demonstration.

UITP and the urban rail transport community consider that the S2R MAAP does not cover key requirements for urban operators.

Even if a lot of development and testing is planned to address urban rail, the lack of urban operators as S2R Joint Undertaking Members participating in the respective TDs can be a weakness of the project. The presence of some rail operators in the open calls or in some of the S2R lighthouse projects can only slightly mitigate this problem. It has to be noticed that, unlike the S2R MAAP, the SRRIA and its roadmap had been designed from the very beginning with the input and agreement of all rail stakeholders' categories.

Moreover, UITP and its urban rail members consider that another problem is that the urban/suburban domains are mentioned in the S2R MAAP without a thorough approach for them, while they would need to be fully integrated in the wider system and technical approach as specific rail market segments.
However, the ERRAC SRRIA (and its implementing roadmaps) is seen as a main guide for the rail community's R&I activities, and ERRAC main associations (e.g. UITP, UNIFE, UIC) are members of the Shift2Rail User Requirements, Implementation and Deployment working group advising Shift2Rail.

9.1 IP1: Cost-efficient and Reliable Trains, including high capacity trains and high speed trains

The domain covered by this SRRIA roadmap corresponds to S2R IP1 "Cost efficient and reliable trains" dedicated to Rolling Stock (RS). Efficiency and Reliability are two major KPIs of S2R corresponding to SRRIA major objectives.

Thus, the S2R overall objectives are nominally aligned on those of the SRRIA RS Roadmap:

- Increase the physical capacity of vehicles to enhance transport capacity of railway lines.
- Reduce the travel disruptions for passengers by increasing operational reliability and availability of vehicles, either through the use of fundamentally more reliable components or system/subsystem architectures.
- Reduce life cycle cost of the vehicle (reduction of maintenance cost, energy consumption) and of other subsystems interfacing with the vehicle (reduction of track damage …).
- Increase energy efficiency of the vehicle and reduce vehicle mass.

Table 2. IP1 - Cost-efficient and Reliable Trains,

SRRIA	MAAP

1.1 - Offering more spacious travelling environment for passengers	
Adaptive interiors configuration for different types of passengers (family activities, mobile office and group travel) and constant evolution (time scale of week, season and society) of the demand (Medium Term)	**TD1.6 of S2R IP1.**
Improvement of interior acoustic comfort for passengers (Medium & Long term)	**TD1.6 of S2R IP1. next generation of sub-systems/components as well** **CCA in which Noise & Vibration is a Work Area.**
1.2 - Increasing vehicle operational reliability	
More reliable system components based on reliable technologies, leading to a highly reliable system which is a prerequisite for the development of track capacity, reduction of in-service failure	**One of 3 S2R core KPIs -- Each development of subsystems/components has a target of improved reliability compared to existing sub-systems/components.** **For example, for the new generation of Traction Drives, the objective is to reduce the number of in-service failures per million km by about 25 %.**
PHM (prognostic and health management) system and condition-based maintenance regimes (Short& Medium Term)	**Apart from a limited Work Area on Smart Maintenance, this topic is not covered in a generic approach in S2R because implementation of Smart Maintenance is already in commercial operations.** **IP1- Maintenance Functionality is tackled in each i.e. Design incorporating Maintenance Functionality**
1.3 - Improving vehicle performance	
Advanced braking (Medium & Long Term)	**IP1- TD1.5 - "Brakes".**
Flexible coupling between consists (Medium & Long Term)	**TD1.2 "TCMS" under wireless coupling between consists.**
Better accessibility to reduce dwell times (Medium &Long Term)	**IP1 - TD1.6 Doors and Access Systems.**
1.4 - Reducing vehicle life cycle costs (including procurement and retrofitting)	
through the combined effect of simpler and more generic and standardised architectures (including interfaces between train sub-systems), less energy consumption (e.g. more energy efficient sub-systems, lighter vehicles and higher level of braking energy recovery), cheaper and more agile certification processes and less maintenance costs. The obsolescence/life cycle of certain RS parts is also included.	**IP1 and CCA**
1.5 - Hybrid Traction	
Multiple power sources including energy storage on-board (Medium Term)	**IP5 - TD5.5 - the development of last mile locomotive.**
1.6 - EE Auxiliaries - Optimisation and development of intelligent management auxiliaries (Short Term)	
Optimisation and development of intelligent management auxiliaries (Short Term)	**S2R does not address directly this topic as breakthroughs are expected from other sectors suppliers e.g. HVAC**
1.7 - Future generation of power semi-conductors	
beyond SIC (Silicon carbide) e.g. diamond (Long Term)	**TD1.1 of S2R addresses the SiC technology and does not cover the diamond technology which is longer term**
1.8 - Innovative Propulsion	
Implementation of hydrogen fuel cell of RAMS/LCC incl. the aspect of hydrogen production & storage (Long Term)	**As breakthroughs with reliable and cost-effective solutions are anticipated from other sectors e.g. automotive industry, this topic is not addressed by S2R**
1.8- Energy and Environment	
Environmental friendly and energy efficient HVAC (Short and Medium Term)	**As breakthroughs with reliable and cost-effective solutions are anticipated from other sectors e.g. automotive industry, this topic is not addressed by S2R**
1.9 - *Environmentally* friendly rolling stock with special emphasis in the reduction of the emission of noise and vibrations and mitigation of their impact	
Improved prediction methods and design solutions to reduce aero acoustics noise of high speed trains (Medium Term)	**This topic is covered in CCA Work Area in N&V**
Reduction of N&V annoyance towards exterior (Medium & Long term):	**This topic is covered in CCA Work Area in N&V.**
1.10 - LCC reduction	
Extending the benefits of LCC reduction to the infrastructure through the development of track-friendly rolling stock technologies	**IP1 - TD1.4 on Running Gears addresses this domain.** **IP5 - TD5.1 of as Technology Deliverables are low-noise, lightweight, high speed & track friendly Freight Running Gears**

1.11- New paradigms for cost efficient freight rolling stock designs with improved capacity and optimised weight and suitable functionalities for different types of freight	
General wagon issues - Modern wagon concepts with low noise, track friendly and more reliable bogies. Increased speed capability with no increased track attrition. Incentives for track friendly equipment (Medium Term)	**IP5 - New wagon design is addressed .**
Freight and Urban Mobility: Interfaces and complementarities: New techniques and vehicles for urban freight delivery (Medium & Long Term)	**IP5 – aspects covered in the freight segment.**
1.12- URBAN, SUBURBAN AND REGIONAL	
Competitiveness and enabling technologies - innovative constituents increasing RAMS whilst decreasing LCC (Short & Medium Term)	**TDs of IP1** **TDs of IP3** **TDs of IP5** **are going to develop the next generation of sub-systems/components with the objectives of increasing RAMS and reducing LCC which are 2 of the 3 core S2R KPIs**
Competitiveness and enabling technologies - Tram-train (Medium & Long Term)	**Tram-Train is a rail market niche already operating with success in different countries. The further development of this segment will benefit from S2R sub-systems/components works. As a full technological segment Tram-Train is not covered by S2R.**
Competitiveness and enabling technologies - Innovative design, devices and constituents (Medium & Long Term)	**TDs of IP1 will develop innovative designs based on cutting-edge technology.**
Research in condition-based maintenance regimes (Short & Medium Term)	
1.13 - RS standards and norms	
Adapting/revisiting RS standards and norms to increase the competitiveness of the railway transport system	**TDs of IP1 will contribute tothe standards/norms dimension**
1.14 - Energy and Environment	
Eco-procurement specifications and harmonisation (Medium Term) allowing e.g. for easier recycling of materials; Eco-design label for rolling stock - Based on key criteria covering significant environmental aspects: Energy-CO2, Materials, Noise (Medium Term)	**Those aspects are not covered directly in S2R although the development of new sub-systems/components is considering e.g. Recycling, Noise & Vibrations, Energy efficiency, etc…**
1.15- Pursuing virtualization of certification/homologation (Medium Term)	**IP1 - this dimension is taken into account at the design stage of the new generation of sub-systems/components**
1.16 - Improving Safety and Security	
Safety - Train collisions preventions and effects mitigation (active and passive safety) (Medium Term)	**IP1 - TD1.3 on "Lighweight Carbodyshell".** **IP2 - Active safety is central in this IP**
Safety – Enhanced vehicle preventive maintenance (short and medium-term)	**As mentioned above, this topic is not covered from a generic approach in S2R for different reasons (except in a CCA Work Area) but all developments are considering this issue e.g. Running Gears**
RTSE	**MAAP**
Full application of common requirements management (shared functional specifications)	**Not covered no direct mention at least**
Common sector standards for the quality assurance methods in the development phase of rolling stock	**IP1 – Cost Efficient and Reliable Trains (introduction)**
Standardised and modular architecture to facilitate interoperable infrastructure and operation	**IP1 - TCMS** **IP1 - Carbodyshell** **IP1 - Brakes** **IP1 - Train Modularity In Use** **IP1 - Door and Access** **IP5 - Wagon design**
Self-powered trains (energy provision and regeneration)	**IP1 - Traction Systems** **IP1 - Brakes** **IP5 - New Freight Propulsion Concepts**
Environmentally friendly technologies (e-mobility, low noise)	**IP1 - Traction Systems** **IP1 - Carbody Shell** **IP1 - Running Gear** **IP1 - Brake** **IP1 - Doors and Access** **CCA - WA5.2 - Noise and Vibration**
Potential of mechatronic technology to improve rolling stock	**IP1 - Carbody Shell** **IP1 - Running Gear** **IP1 – Brake**

Fitness for redesign and sustainability, i.e. modular white box approach and design-sensitivity against obsolescence: long-term stable standardised interfaces (mechanical, electrical, data, performance,…) inside rolling stock, between vehicle and with the infrastructure interface	**IP1 - Train Modularity In Use** **IP1 - Doors and Access Systems Demonstrator ☑** **IP1 - Traction System**
Freight	
Better brake performance	**IP1 - Brakes** **IP5 - Freight Electrification, Brake and Telematics**
Introduction of central couplers for easier assembling and reduction of pull and stress forces between wagons	**IP1 - TCMS** **IP2 - Moving Blocks** **IP2 - Virtual Coupling** **IP5 - Business analytics and implementation strategies** **IP5 - Freight Electrification, Brake and Telematics** **IP5 - Wagon design**
Distributed traction power	**IP1 - Traction Systems**

9.2 IP2: Advanced Traffic Management & Control Systems

The domain covered by the SRRIA CCC (Control Command and Communication) roadmap corresponds to S2R IP2 “Advanced Traffic Management and Control Systems”. Capacity and Reliability are two major KPIs of S2R corresponding to SRRIA major objectives.

Thus, the S2R overall objectives are nominally aligned on those of the SRRIA CCC Roadmap:

- Increase capacity through real-time intelligent traffic management systems
- Reduce energy consumption
- Increase operational flexibility
- Reduce life cycle costs through cost effective standard design, test, installation and maintenance of signalling and communications need of an open architecture
- Keep the current high level of safety in the rail networks and ensure cybersecurity while increasing networked interconnections
- Improve performance in terms of reliability and punctuality as well as information (e.g. traffic information/disturbances)

The SRRIA Roadmap on Control Command and Communication identifies mega objectives that are covered by the S2R IP2 ‘Advanced Traffic Management and Control System”

- Real time traffic management capabilities for increased capacity, energy efficiency and sustainability.
- Robust and cost effective standard design, test, installation and maintenance of signalling infrastructures
- Future generation of train control systems focusing on: autonomy, enhanced train location knowledge (e.g. on-board/trackside-less train location and train integrity) and its impact in capacity, environmental gains (i.e. limiting pollution) and operational costs.

The 11 TDs of S2R IP2 “Advanced traffic management and control system” will address those topics except the maintenance of signalling infrastructure.

Table 3: IP2 – Advanced Traffic Management and Control Systems

SRRIA	MAAP
Many R&D topics identified in the SRRIA are nominally covered by the S2R IP2 activities.	**IP2**
RTSE	**MAAP**
The use of satellite-based services such as train positioning	**IP2 - Fail-Safe Train Positioning (including satellite technology)**

Standard CCC components hardware/software with safety mechanisms	**IP1 - TCMS** **IP2 - Cyber Security**
Improved interfaces for CCC subsystems • Rolling stock : on-board equipment linked with the CCC, modular structure • Infrastructure : clear and comprehensive architecture"	**IP1 – TCMS** **IP2 – Adaptable communications for all railways** **IP2 – Moving Blocks** **IP2 – Virtually – coupled train sets**
Implementation of a systems engineering approach to develop standardised systems	**IP1 - TCMS** **IP2 - Cyber Security** **IP2 - Formal Methods and standardisation for smart signalling systems** **IP2 - Traffic management evolution** **IP2 - Smart radio-connected all-in-all wayside objects**
Wireless data transfer for confirming train completeness	**IP2 - On-board Train Integrity**
Formal methods for specifications development of train control equipment/sub-systems	**IP2 - Advanced Traffic Management and Control Systems** **IP2 - Smart procurement and testing** **IP2 - Formal methods for smart signalling system**
"Internet of things" / Rail internet	**IP2 - Traffic Management Evolution** **IP2 - Smart radio-connected all-in-all wayside objects** **IP3 - DRIMS** **IP4 - Interoperability Framework** **CCA - WA3 - Smart Maintenance**
Remote obstacle detection	**IP3 - DRIMS** **IP5 - Autonomous train operation**
Standardised approach to remote diagnostics	**IP1 - Traction Systems** **IP3 - DRIMS** **IP3 - RIMMS** **CCA - WA3.2 - Standardisation** **CCA - WA3.3 - Smart Maintenance**

9.3 IP3: Cost-efficient, Sustainable and Reliable High Capacity Infrastructure

This domain covered by the SRRIA roadmaps corresponds to S2R IP3 “Cost-efficient, Sustainable and Reliable High Capacity Infrastructure” and also some Work Areas of S2R Cross Cutting Activities.

The S2R IP3 is aligned with the following objectives:

- enhancing the existing CAPACITY fulfilling user demand of the European rail system;
- increasing the RELIABILITY delivering better and consistent quality of service of the European rail system;
- reducing the LIFE CYCLE COST (LCC) increasing competitiveness of the European rail system

The overall technical KPIs to characterize these objectives are:

- Overall LCC and RAMS
- Track performance and traffic disturbance
- Environmental performance

The corresponding societal benefits include:

- Capacity
- Operational reliability
- Competitiveness – share of transports

Table 4: IP3 - Cost-efficient, Sustainable and Reliable High Capacity Infrastructure

SRRIA	MAAP
3.1 - Construction and Maintenance of Infrastructure	
Novel materials, resilient materials for use in track forms and increased use of recycled materials	**IP3 - TD 3.3 - use of new materials and introduction of re-used / recycled materials into the design and construction process.**
Adoption of new processes and technologies such as self-healing nanotechnology based materials for use in structures	**IP3 - TD 3.2** **CCA - WA 3.4 the study and evaluation of the maturity of smart materials like nanomaterials , self-healing, adaptive and active**
Modularisation of infrastructure assets and components	**IP3 - TD 3.4 achieving interoperability through modularisation, standardisation and a harmonised assessment methodology for innovative solutions.**
Effective monitoring and automation of rapid maintenance processes using trackside systems for remote condition monitoring, inspection by robots, UAVs, hybrid air vehicles and satellites and use of service trains for regular inspection	**IP3 - TD 3.1 of through the integration of remote condition monitoring with a feedback loop for self-diagnosis and adjustment, and in** **IP3 - TD 3.7 with innovative drone- and/or satellite-based remote-sensing measuring and monitoring tools (RMMS).**
Improved algorithms for predictive analysis and timely intervention, understanding infrastructure failures, leading to reduction in asset whole life cost	**IP3 - TD 3.7 of by measuring relevant data using the most innovative techniques, processing data in order to generate relevant maintenance infrastructure-related information, generating data/information to feed** **IP3 - TD 3.6 and 3.8 models/algorithms to support maintenance and asset management processes.**
New knowledge in rolling contact fatigue and other defects in the rail head such as rail corrugations	**IP3 - TD 3.3 of aiming to an enhanced understanding of Rail Contact Fatigue, squats and also wear, obtaining a significant extension of life cycle.**
Novel simplified switch and crossing designs to capitalise on the development of mechatronic bogies, more reliable, quiet and that allow higher speeds. New user-centric crossing designs.	**IP3 - TD 3.1 and** **IP3 - 3.2 of which considers a whole-system approach to S&C design and incorporates modern mechatronics for improved system kinematics and control.**
3.2 - Infrastructure based supporting systems and services	
Reliable and resilient infrastructure where remote condition monitoring and risk based maintenance are the norm and supported by coherent and cooperative maintenance planning	**IP3-Cost Efficient, Sustainable and Reliable Infrastructure.**
Intelligent Infrastructure able to monitor, manage and in some cases self-repair itself	**IP3 - TD 3.8 theoretical processes about asset behaviour and degradation, asset management theories and individual maintenance strategies for specific sub-systems to the actual work outside in the operational process.**
Situational Awareness to prevent costly failure and to support predictive maintenance, information and intelligence is needed to assess emerging situations and novel and innovative interventions applied before criticality is reached	**IP3 - TD 3.6 of dealing with automatic detection of anomalies in the status of asset(s) based on the analysis of measured data and** **Its evolution in time in order to predict in advance (now cast and forecast) potential** failures or drifts and to define the "normal behaviour".
Instrumentation for new inspection technologies, remote monitoring and health assessment of tunnels, embankments and bridges. Portable on-board monitoring systems connecting infrastructure data and vehicle performance	**IP3 - TD 3.5 of which aims to improve the inspection methods in tunnels, embankments and bridges,** **IP3 - TD 3.7 which aims to develop asset-specific train-borne measuring and monitoring systems (TMMS) for infrastructures.**
3.3 - Governance, management and finance of the infrastructure	
Optimise Performance**: i**ncrease infrastructure systems ability to work together and with adjacent systems (e.g. modal exchange systems) in a seamless and intelligent manner and increased ability to manage weather extremes and climate change	**This topic is partially covered by TD 3.11 of IP3 facilitating interoperability by higher capacity, and more reliable rail operations that enhance the logistic reliability in cross-modal transports and in TD 3.4 enhanced capabilities to adapt to climate changes including short-term extreme-weather, temperature variations.**
Whole Journey Connectivity: the railway is a key part of international end-to end journeys for passengers and freight, it needs to provide a high quality and seamless modal interchangeability, without unnecessary delay and minimum regulation	**CCA - Work Area 1 - Long-term needs and socio-economic research.**
Freight Access: make it increasingly easy for freight operators to access increasingly capacious freight (and passenger) terminals and	**IP5 - Optimization of operational freight processes - infrastructure, operations and assets; automation of rail freight**

then see their freight loaded, moved and unloaded swiftly using automated processes, along with an increase in the ability to move freight across international borders on environmentally friendly and fast freight trains that deliver into multi-modal logistic chains	**system and new markets.**
RTSE	**MAAP**
Future slab track system	**IP3 - Optimised Track System**
Cross-modal transport infrastructure management system	**IP3 - Smart Metering for Railway Distributed Energy Resource Management (energy-only, marginal)** **IP5 - Novel Terminal, Hubs, Marshalling Yards, Sidings ~ (in an extremely marginal way, so topic not covered)** **CCA - Work Area 4 –Smart Mobility ~ (railcentric)**
Optimisation of maintenance planning and scheduling	**IP3 - DRIMS** **IP3 - IAMS** **CCA - WA3 - Smart Maintenance** **CCA - WA 4.1 - Smart Planning**
New developments and concepts for switches and crossings	**IP3 - Next Generation Switches & Crossings System** **IP3 - Next Generation Track System**
Security of infrastructure materials and components	**Not related**
Innovative ballasted and non-ballasted track-form designs	**IP3 - Optimised Track System**
Overcoming infrastructure limitation to heavy and long-trains	**IP2 - Virtually – Coupled Train Sets (VCTS)** **IP5 - Wagon design** **IP5 - New Freight Propulsion Concepts**
Non-intrusive infrastructure monitoring	**IP3 - RIMMS** **IP3 - Smart Metering for Railway Distributed Energy Resource Management**
Modular "plug-and-play" design of infrastructure	**IP3 - Enhanced Switch & Crossing System** **IP3 - Next Generation Switch & Crossing** **IP3 - Optimised Track** **IP3 - Next Generation Track System** **IP3 - Smart Power Supply** **IP3 - Future Stations** **IP5 - Novel Terminal, Hubs, Marshalling Yards, Sidings** **CCA - WA3.2 - Standardisation**
Optimised noise and vibration control	**IP3 - Enhanced Switch & Crossing System** **IP3 - Next Generation Switch & Crossing** **IP3 - Optimised Track** **IP3 - Next Generation Track System** **IP3 - Proactive Bridge and Tunnel Assessment, Repair and Upgrade** **CCA - WA5.2 - Noise and Vibration**
Use of wireless progressive telecommunications to enhance operation, maintenance, passenger support and make possible intelligent trains and intelligent stations	**IP2 - Smart radio-connected all-in-all wayside objects** **IP3 - DRIMS** **IP3 - RIMMS** **IP3 - IAMS** **IP3 - Future Stations**
Development of technologies for facilitating the operation of services between systems with gauge differences - speeding up the changeover process	**IP1 - Running Gear**

9.4 IP4: IT Solutions for Attractive Railway Services

Federated IT across the European Union to deliver timely data and information enabling a quantum change in overall operational efficiency and service delivery is of paramount importance for the rail transport sector.

Improving the passenger and freight end-to-end journey experience requires a step change in the speed, efficiency, quality and exploitation of data and information by European railways. IT and other enabling technologies provide a huge opportunity to raise service quality but will also be used by the railway's competitors, so are critical to its future attractiveness and success.

Challenges Addressed:

Freight: Integrate freight IT systems to provide live tracking and monitoring of freight status and position, supplying the information and intelligence to the supply chain.

Passenger: Provide real time access, through push and pull technologies, to an increasing range of general, bespoke and personal services aimed at informing and entertaining the passenger before, during and after their end-to-end journey

Mainline: Exploit 'big data' and associated data and information flows, especially relating to asset and service status

Urban Mobility: Use IT and other technologies to reduce the stress of urban journeys

Urban, Suburban and Regional Rail: Optimise and homogenise (big) data flows between types of rail sector services to improve interoperability and modal Interconnectivity with adjacent transport providers.

Safety and Security: Ensure that IT systems are designed to meet safety needs and able to stay ahead of security risks, especially cyber threats

Strengthening Competitiveness: Exploit real and near real time customer data and intelligence to improve and increase services offered.

Improvements to whole life asset management and especially development of increasingly accurate predictive tools associated with asset management in order to Strengthen Competitiveness of rail services and solutions.

The value of modern IT for customer and operational purposes is large. Better connectivity will result in customers perceiving rail as good value for money and their increasing patronage will generate more revenue. Coherent IT practices and shared approaches can have a value added impact by reducing capital and ongoing operating costs, for instance for infrastructure renewals / upgrade programs – estimated at 5-10% of the program budgets, conservatively worth hundreds of M€ in future investments.

Table 5: IP4 – IT Solutions for Attractive Railway Services

SRRIA	MAAP
4.1 Freight	
Intelligent traffic management - Introduction of new intelligent management systems capable of optimizing the use of the existing infrastructure	**IP5 -TD 5.6 "Autonomous Train Operation (ATO)" will develop a demonstrator of rail freight automation, building on base technology developed within the S2R** **IP2- TD 2.2 "Railway Network Capacity Increase (ATO up to GoA4 – UTO)".**
Freight wagon telematics	**IP5 - TD5.1 "Freight electrification, brakes and telematics" covers that aspect. Telematics applications and electrification built on TAF TSI standards will provide new and innovative functionalities on real time monitoring and tracking of cargo for logistic purposes and provide information to TMS about the convoy (End of Train - EoT), real time conditioned monitoring (wagon and goods), automatic train set-up functionalities and information to the driver.**
Automation - prerequisites for automated loading-/unloading of waggons (respective installations on waggons, planning & controlling systems) and/or automated coupling-/de-coupling, automated controls/train ready messages)	**IP5 - T5.1 "Freight electrification, brakes and telematics will cover Automatic coupling of wagons**
Logistic services - Rapid reaction to queries - response time to enquiries in terms of service availability, routes, schedules, pre and end haulage satisfying customer demands	**IP5 - TD 5.2 "Access & Opeartion" - Logistic services - Rapid reaction to queries - response time to enquiries in terms of service availability, routes, schedules, pre and end haulage satisfying customer demands"**

Fleet Management - Reduction of empty running and repositioning of equipment	**Not covered by S2R.**
Fleet Management - Open standard rail freight management of ICT packages compatible with other operators - enabler of train planning and collaborative approach	**Not covered by S2R.**
4.2 Passengers	
Development of a digital interoperability framework - based on web semantics technologies, it allows the decoupling of interoperability mechanisms from the application layers, and is a key condition to foster multimodal interoperability without further standardization	**IP4 - "Solutions for attractive railway services"**
Seamless multimodal travel experience - Harmonization of shopping, booking, ticketing and travel information, ticketless journeys (EU level) interoperable with local transport fare management systems	**IP4 - "Solutions for attractive railway services"**
Passenger Experience - Enhanced access to all travel services and ancillary experiences, including shopping/booking/ticketing, but also information, en-route assistance and re-accommodation, trip-tracking, and additional services related to the journey	**IP4 - "Solutions for attractive railway services**
Improving traffic/mobility management. Disruption and recovery management, on-demand/offer	**This is covered by System Mobility Management (S2M)**
4.3 Main Lines	
ERTMS-level 3 fully implemented on core axis (TEN-T) - Development and implementation of processes and ICT tools for time tabling and operational traffic management	**Not considered by S2R as a R&D topic but an implementation related one.**
GNSS used as positioning system fully compatible with ETCS	**GNSS used as positioning system fully compatible with ETCS**
Signalling in the cloud, with limited ground equipment: the train knows (GNSS or other sensors) its position, communicate it to the ground, and the train movement is controlled remotely thanks to an overall traffic management system	**This is covered by several TDs of IP2 "Advanced traffic management and control system".**
4.4 Urban Mobility	
Freight and Urban Mobility: Interfaces and complementariness - New city-logistic concepts	**Not covered by S2R**
Integrated Urban/Mobility Systems and Governance	**Not covered by S2R**
Interoperable ticketing, traffic and travel information: governance aspects and interoperable innovative technologies, tools and products	**IP4 "Solutions for attractive railway services".**
Innovative technologies, tools and products - Interchangeable and/or interoperable innovative technologies, tools and products, for traffic and travel information: Innovative technologies, tools and products - Interchangeable and/or interoperable innovative technologies, tools and products, for traffic and travel information.	**CCA I2M (Integrated Mobility Management) : specify, develop and integrate all necessary Elements into the Traffic Management System to integrate actual and forecasted Traffic Asset and Freight Operations status information into a seamless operation process**
Interoperability for customers through multi-applications on a single support: create a Pilot operation in a number of Member States in preparation for wider roll-out	**Not covered by S2R**
Develop a Common EU portal and Common Product Templates supporting an extension of the "IFM Brand":	**Not covered by S2R**
Create a common EU-IFM application (T2-T3), and develop a commercial and technical framework for the sales and settlement of EU-IFM Products	**Not covered by S2R**
Extend functionalities to facilitate inter-modality and Demand Management	**Not covered by S2R**
Engage and merge with existing IFM Systems and other ITS services and transport modes	**Not covered by S2R**
Engage with applications for electro-mobility related services	**Not addressed**
Security and privacy framework for contactless payment	**The objective of S2R is NOT to develop those technologies which are better developed by the ICT companies and researchers.**
(New) charging and pricing policies strategies	**Not covered**
4.5 Urban, Sub-urban and Regional	

Competitiveness and enabling technologies - Innovative ITS for operation management	Not covered.
Personal safety/security - ITS for passenger security and safety	Not covered
Competitiveness and enabling technologies - Information management (databases, dynamic control of information	Partly covered
RTSE	**MAAP**
Information Management	
Shared information platforms and robust IT tools that make possible real-time data exchange between rail service providers and other transport modes	IP4 - Interoperability Framework CCA - WA 4.2 - Integrated Mobility Management (I2M)
Production of common interface standards to ensure that the customer experience is seamless	IP4 - Interoperability Framework IP4 - Travel Shopping IP4 - Booking&Ticketing CCA - WA 4.2 - Integrated Mobility Management (I2M)
Coherent management policies and protocols, together with the clear identification of data owners and development leaders	IP4 - Interoperability Framework CCA - WA 4.2 - Integrated Mobility Management (I2M)
Support for the real-time management of a system that is resilient to external influence	IP2 - Cybersecurity IP4 - Interoperability Framework CCA - WA 4.2 - Integrated Mobility Management (I2M)
Customer experience applications developed for both passengers and freight, and brought to the customer by a vibrant competitive market of innovative, independent suppliers.	IP4 - Travel Shopping IP4 - Booking&Ticketing IP4 - Trip Tracker IP4 - Travel Companion
Access to continuous data, allowing passengers to treat their journey as a seamless extension of their working or leisure environment	"IP4 - Interoperability Framework CCA - WA 4.2 - Integrated Mobility Management (I2M)
The concept of end to end journey applies (journey / shipment planner, seamless / contactless ticketing / tariff arrangements, journey/shipment tracking)	IP3 - Future Stations IP4 - Travel Shopping IP4 - Booking&Ticketing IP4 - Trip Tracker IP4 - Travel Companion
Seamless ticketing without queues or physical barriers at stations	IP3 - Future Stations IP4 - Travel Shopping
Electronic systems (smartphones etc) for revenue collection and security controls based on electronic systems	IP3 - Future Stations
New information technologies on board trains and at the station	IP1 - TCMS IP1 - Doors and Access Systems IP1 - Train Modularity In Use IP3 - Future Stations CCA - WA 4.2 - Integrated Mobility Management (I2M) CCA - WA 6 - Human Capital - Customer oriented design of mobility

9.5 IP5: Technologies for Sustainable & Attractive European Freight.

The IP5 of S2R is covering the topics that can lead to better efficiency of the rail freight business. In the SRRIA there is no Road Map specific to freight that is scattered in different roadmaps such as Rolling Stock, CCC, IT, etc…

S2R is addressing the following key topics:

- Enhanced electrification and digitalization: Freight electrification, brakes and telematics;
- Access and operations: Improve accessibility to rail freight and provide highly reliable and flexible solutions to compete with the maritime and continental intermodal transport.
- Wagon design: Develop and demonstrate the next generation of freight bogie and freight wagon.

- Novel terminals, hubs, marshalling yards and sidings: Novel terminals for improved data gathering, steering, operation and coordination of intermodal transport with a terminal design that allows efficient change of transport modes and the hybridization of the legacy shunting fleet operating in marshalling yards and sidings by means of retrofitting.
- New freight propulsion systems: New powerful EU freight locomotives with flexible and network independent operation capabilities, supporting increased train lengths up to 1500m and reducing massively energy consumption, thus providing more attractive rail freight services to the final customer with competitive operating and maintenance costs.
- Autonomous Train Operations: Building on base technology developed within TD 2.2 (ATO GaO 4) to actively pursue the objective of Autonomous Train Operation (ATO) realized progressively until 2030, for mainline freight operation and the underlying operations.

Table 6: IP5 – Technologies for Sustainable & Attractive European Freight

SRRIA	MAAP
Urban freight	Not covered by S2R
Long distance freight	IP5 - All topics are covered by this innovation Program
RTSE	**MAAP**
Better brake performance	IP1 - Brakes IP5 - Freight Electrification, Brake and Telematics
Introduction of central couplers for easier assembling and reduction of pull and stress forces between wagons	IP1 - TCMS IP2 - Moving Blocks IP2 - Virtual Coupling IP5 - Business analytics and implementation strategies IP5 - Freight Electrification, Brake and Telematics IP5 - Wagon design
Distributed traction power	IP1 – Traction systems

9.6 Energy and Environment

The European Railway sector has an important role to play in minimising its impact on the environment through managing its energy related emissions and securing continuity of supply in order to provide a reliable service, and in using available resources in a highly effective and efficient manner

Challenges Addressed:

Rolling Stock: Increase use of hybrid energy solutions to give increased operational range and flexibility and reduced dependence on diesel fuel along with increasing energy efficient, lighter, trains with low-loss traction systems, plus increasing focus on 'emission hot spots' (e.g. idling diesels, unplanned stop / start).

Infrastructure: Introduce and then maximise benefit from managed electricity supply using SMART Grid technologies coupled with increasing the resilience and variety of supply resources (e.g. main grid, local renewable, recovered, etc.), with reduction of associated environmental impacts.

Operations and Management: Deliver advanced driving capability coupled to intelligent and adaptive traffic management systems to reduce energy consumption and increase energy

efficiency, and that realise associated environmental benefits associated with noise, vibrations and emissions.

Support and Communication: Implement of pan-European systems to report on energy and environmental metrics and co-operative approaches to tackling the issues of extreme weather and climate change

Technology and Innovation Needed:

Rolling Stock consumes a significant proportion of the energy used by the railway and needs to continuously improve its efficiency and effectiveness in converting energy resources into traction and on-board services. The associated three key areas for technology and innovation identified are:

- Lighter Trains: the use of mechatronic systems, lighter materials and innovative approaches to weight reduction are envisaged
- Hybrid Traction: innovative technology applied to improving diesel fuel engines is required, along with the development and incorporation of hybrid energy solutions that maximise operational effectiveness. Energy resources, especially their resilience and availability for traction drive are a focus for innovation and in reducing the rolling stock contribution to environmental impact
- EE Auxiliaries: Technology and innovation to reduce energy consumption of on-board systems (heating, lighting, etc.) are needed.

Infrastructure covers energy distribution, energy generation and energy usage, especially at stations. Technology and innovation is required for:

- SMART Grid and energy harvesting: Management of energy distribution systems that maximise efficiency and report, in a qualitative manner, are required to in order to demonstrate effective energy usage thus a Pan-European approach to SMART Grid technology and innovation is envisaged.
- Advanced Traction Energy Supply: Sustained and efficient Energy Supply for rolling stock traction is critical for railway operations and innovative and technological advances in electrical energy distributions, development of higher voltage systems is anticipated, plus an increasing ability for regenerated energy to be returned to the grid;
- Non-Traction Energy: Innovative ways are required to realise the belief that there is considerable potential for locally generated and renewable energy resources to be used to power local non-traction systems, especially at stations and terminals; further, excess energy could be used/sold for local consumption.

The key requirement for Operations and Management is to increase and steadily improve management of rolling stock, enabling it to be driven more efficiently and in an eco-friendly manner, specifically:

- Traffic Flow Management: Innovative ways for reduction of energy consumption and environmental impact through integrated traffic management;
- Communications between Traffic Management System(s) (TMS) & Driver Assistance System(s) (DAS): Develop systems that increase the energy efficiency of driving through DAS supported driving and real time links with TMS

Three areas for technology and innovation have been assigned to Energy and Efficiency Support and Communication:

- Noise and Vibration: There is a need to reduce noise and vibration levels across the railway and reduce associated impact on the environment, and in part as a pre-requisite for 24 hour operation
- Energy & Carbon reporting: The European railway needs to measure its energy efficiency and effectiveness in coherent and uniform ways to enable it to consider areas for action, as well as understanding its impact on environment.
- Climate Change: Increased incident of weather extremes and climate change will impact the railway. Technology development is necessary to provide climate resilience and the ability to operate and recover from extreme weather related events. Technologies that protect infrastructure and trains from heat, water (rain, snow, ice, flood, etc.), and allowing a degree of end-to-end journey provision are sought

Table 7 – Energy and environment

SRRIA	MAAP
Rolling Stock: * Increase use of a hybrid energy solutions to give increased operational range and flexibility and reduced dependence on diesel * Increase energy efficiency: lighter, trains with low-loss traction systems, plus increasing focus on 'emission hot spots' (e.g. idling diesels, unplanned stop / start).	S2R is not addressing hybrid energy solutions. **TD1.1 on the New Generation of Traction Drive will result in low-loss traction systems.** **Hybridation of shunting loco is partly covered in IP5.** **S2R partly addresses on-board Energy Storage System.**
Infrastructure: Introduce and then maximise benefit from managed electricity supply using SMART Grid technologies coupled with increasing the residence and variety of supply resources (e.g. main grid, local renewable, recovered, etc.) , with reduction of associated environmental impacts.	**The objective of TD3.10 is to utilize the technologies developed by the Smart Grid business to better manage rail energy supply and increase energy efficiency.**
Noise & Vibrations	**This critical issue for the railway business is only covered by the different TDs, especially IP1 and IP3 but also through a specific Work Area in the CCA.**
Climate change	S2R is not covering that topic but S2R results should have an influence.
RTSE	**MAAP**
SYSTEM	
Smart grids that aid the storage of energy and adaptive feeding	**IP3 - Smart Power Supply** **IP3 - Smart Metering for Railway Distributed Energy Resource Management**
Power supply infrastructure that provides harmonised management of operational status of the electric railway from a core-supply control network	**IP3 - Smart Power Supply** **IP3 - Smart Metering for Railway Distributed Energy Resource Management**
Sustainable energy-procurement - careful consideration of environmental and societal aspects as well as the economic aspects when carrying out the investment process	**IP3 - Smart Power Supply**
Monitoring and analyzing the sector's emissions	**CCA - WA 5.1 - Energy** **CCA - WA 5.2 - Noise and Vibration** Not lasting monitoring of emissions seems to be foreseen
Trains	
Recovery of energy from trains (regenerative braking systems	**IP1 - Brakes** **IP5 - New Freight Propulsion Concepts**

Minimising energy consumption through green driving techniques	**IP5 - Freight electrification, brakes and telematics**
Zero-emission trains	**Reduction of emissions is foreseen in several places (notably IP5) but no "zero-emissions train"**
Infrastructure	
The reduction of negative environmental impacts from materials	**IP3 - Enhanced Switch & Crossing System** **IP3 - Optimised Track** **IP3 - Smart Power Supply** **CCA - WA 5.1 - Energy**
Close cycle waste management systems for a high level of recycling	**IP3 - Optimised Track System** **IP3 - Next Generation Track System**
Plans to remove the historical legacy of existing infrastructure (e.g. creosote sleepers)	**No correspondence**
Plans to reduce pollution from rail sources (e.g. chemical treatment against vegetation)	**No correspondence**
Technology to reduce the intrusion of electromagnetic waves	**IP1 - Traction Systems**

9.7 Training and Education – Human Capital

A partnership for innovation, skills development and jobs is envisaged to mobilize support and help the different players work together to spread ownership and excellence.

The sector is getting increasingly impacted by new processes and technological changes, and complex simulation tools and ICT applications are getting more and more important. These trends will play an important role in regard to future skills.

Knowledge transfer from other sectors is also an important aspect of the future of rail transport's cross-sectorial approach: even though partnerships may be assigned to a specific sector, they often work across different business sectors.

Training and skills development is a necessary pre-condition for the success of both the European Research challenges and the everyday needs that the railway sector is facing. Training and education initiatives offer an effective way to nurture collaboration across the sector by:

- Providing access to industrial sector and promote knowledge transfer processes from academia and research institutions through specific actions and research based training and education initiatives.
- Provide the dissemination of experience and best practices among the stakeholders of the same sector, in order to learn from the lessons of each other.
- Fostering collaboration and joined-up thinking by facilitating sustainable partnerships involving the sector, SMEs, academia and R&D institutions.
- Facilitating cross-fertilization from other sectors aiming to intermodal integration by cooperating with ETPs and other stakeholders from the transport sector.

Key objectives in training and education activities are:

- Forecasts of the skills that the railway sector will need and analysis of gaps in skills;
- Enhance and expand access to railway educational programs and courses;
- Enhance educational quality in the railway area (academic, stakeholders);

- improve cooperation between the railway sector and educational institutions to put forward courses not offered by existing institutions;
- Develop e-learning based courses and promote the production of course materials;
- Promote Joint PhDs using bilateral and multilateral programs;
- Promote joint international MSc programs in different rail related areas;
- Develop and deliver short training courses (STC);
- Facilitate sustainable partnerships involving the sector, SMEs, academia and R&D institutions envisaging knowledge transfer and fostering innovation processes

Furthermore, UITP and the urban rail stakeholders consider that urban operators' representatives had a limited and rather late involvement in the definition of this topic, and their foreseen involvement remains through open calls or tenders. Authorities and other relevant stakeholders have also not been involved in the process from the beginning, and their input is made possible in the same manner. By corroborating these aspects, the conclusion to be drawn is that good results can be achieved through the proper inclusion within S2R of the relevant missing actors – through open calls and/or tenders. Future initiatives at a level similar to S2R should avoid this delayed mitigation process by including all stakeholders from the beginning.

Table 8 – Training and Education – Human Capital

SRRIA	MAAP
1. Characterisation of skills and competence needs	
State-of-art and current trends in the development of technically and operationally inter-dependent systems, production methods and industry structure, value added and changes in volume trends, employment trends	**Master Plan objectives – Improved services and customer quality. Task W6.0.1** **includes methodological approaches, practical experiences, analysis of the "gaps" in qualification and skills, strategies to mitigate potential negative effects and to adopt new organisational design approaches with the goal to match changes in technology with changes in job profiles.** **MP1 – Improved reliability** **MP2 – Enhancing capacity** **MP3 – Customer experience** **All activities within the WA "Human Capital" support the goal toward "improved reliability" (MP1) even under uncertainty or extreme conditions. Enhanced performance of the operators will also lead towards the goal "Enhancing capacity" (MP2) and "Customer experience" (MP3).** **Analysis of the "gaps" between the current and future skill and performance requirements and potential skill degradation Development of strategies to mitigate potential negative effects on operator skills and to assure the appropriate skills for the job Training (vocational & recurrent) Crew resource management: How will new technologies affect the interaction between operators (e.g. the interaction between train drivers and train controllers when the train driver uses a decision support tool that advises him/her of optimal speeds/breaking points, timetabling and maintenance schedule planning etc.)?** **Personnel selection: How will the introduction of new technologies affect the selection of personnel?** **System design: User-centred design, adaptive automation**
Internal competition between modes (and even within mode sectors), which give a new dimension to skills development and	**Master Plan Objectives – Reduced system costs** **The goal of this task is to elaborate approaches in the realm of**

changing trends in staff requirements while the legal and regulatory environment is becoming also more relevant requiring specific skills and knowledge in specific issues e.g. those in the safety domain;	**jobs, qualification and organisation. This includes methodological approaches, practical experiences, analysis of the "gaps" in qualification and skills, strategies to mitigate potential negative effects and to adopt new organisational design approaches with the goal to match changes in technology with changes in job profiles.** **MP4 Lower investments costs** **MP5 Reduced operating costs** **MP6 Externalities** **All activities within the WA "Human Capital" support the goal toward "improved reliability" (MP1) even under uncertainty or extreme conditions. Enhanced performance of the operators will also lead towards the goal "Enhancing capacity" (MP2) and "Customer experience" (MP3).**
Technical competences associated with: professional intervention across different railway assets; appraisal of the level of intervention in technical careers; new emerging technology products and services such as Galileo, GSM, IT, environmental efficiency; systems engineering, man-machine interfaces and human factors, signaling systems, innovative and modular RS, modern infrastructure maintenance, sensor technologies and asset management methods;	**The effects of digitisation and automation on the job profiles; Shift2Rail MULTI-ANNUAL ACTION PLAN – Part 3 811** • **The change of qualifications and skills due to new technologies and specific training programmes;** • **The consequences on employees' flexibility and autonomy of the setting-up of more agile organisations; Customer-oriented design of mobility.** **For all topics, knowledge transfer from other sectors and benchmarking with industries or sectors that are already highly automated are expected to ensure synergies with regard to skills that are not specific to the railways.**
Competences in the legal domain: interoperability directives, safety rules, certification of rail staff, environmental policies, working conditions, etc.;	**This task will be an open call: In order to carry out these research topics with Shift2Rail MULTI-ANNUAL ACTION PLAN – Part 3 813** **Task Name Task Description** **Different point of views, we will need to associate competences in organisational sciences, human resources and management sciences, safety sciences, demography, sociology, ergonomics, cognitive psychology and economy.**
Competences in procedures and operational cooperation in different market areas: competition, social objectives, customer demands, cross border operations, liberalization, low fare airlines, globalization, freight logistics and related passenger and freight services.	**Proven knowledge of the railway system** **Proven knowledge of job profiles in the railway system Good knowledge of technical developments in the area mentioned above (e.g. Big Data, Optimisation and Simulation with intelligent IT-Systems, robot-assisted production and maintenance etc.) and the effects of such developments on human operator performance and job profiles in general as well as in other highly-automated industries or sectors Excellent command of the English language and capability to work with an international team** **Excellent documentation skills excellent oral and written presentation skills**
2. Higher education offer **3. Advanced Training courses**	
Update and develop a comprehensive inventory of current railway higher education programs and activities in the E.U. and the rest of the world,	**Not covered**
To determine the demand for railway higher education by the operators, infrastructure managers, transport authorities and the industry, both quantitatively and qualitatively.	**Task W6.0.1**
Appraise current educational offers and define major guidelines at BSc and MSc levels bridging the gaps between knowledge production in Higher Education institutions and required know-how in the different industrial environments. Establishment of training and education for top management in the sector.	**Not covered**
RTSE	**MAAP**
Railway People	
A Europe-wide education platform for all levels (young professionals, experts, senior and top management) offering tailor-made programs that cover the needs of the sector to reduce people	**Not covered**

costs at company level	
A coordinated standardisation framework and a network of best practices to reduce the costs of implementing new products	"Yes, e.g.: IP2 - Cyber Security (cybersec-experts network) IP4 - Trip Tracker (coordinated standardisation framework) CCA - Work Areas (not. WA 3) (coordinated standardisation framework)
Research institutes, industry and the ROC are used to develop good products and import best relevant practice based on activities from other sectors/industries	"Yes, e.g.: IP2 - Adaptable communications for all railways IP2 - Cyber Security CCA - Work Area 6 – Human Capital
Product / concept deployment strategies that include explanations of the system and human impact and how to implementing the innovation with human resources / existing knowledge	CCA - Work Area 6 – Human Capital
Modern IT-based knowledge management systems to preserve and spread relevant information about railways and to structure and guide decentralised coherent collaboration, e.g. requirements management	Not covered
Assessment of the skills requirements for the future railway	CCA - Work Area 6 – Human Capital
An open and balanced collaborative process for the recruitment and transfer of staff	CCA - Work Area 6 – Human Capital
Improved learning methods to maximise benefits from new technology	Not covered
Technology and roles designed with people in mind and a clear identification of the user and what is his / her need	CCA - Work Area 6 – Human Capital
The automation of repetitive and arduous tasks and management of the interface between man and machine	IP5 - Autonomous Train Operation CCA - WA3.1 Safety CCA - WA6 Human Capital

9.8 The other transversal Themes / CCA

The objective of the CCAs is to ensure that the R&I activities within the different IPs are closely integrated in terms of their objectives and requirements, as well as in terms of the methodologies to be used for evaluating and assessing the expected impacts. These activities include elements already taken into account in the different Innovation Programmes that require horizontal coordination, such as energy and noise management, safety, standardisation, overall traffic management, maintenance, virtual certification, as well as long term societal effects and human capital management.

Furthermore, the CCAs will carry out the additional research needed to complement and leverage S2R technical work carried out in the different IPs.

The interactions between the different IPs will be of major importance, given that evolutions in technology in one part of the system managed by a specific actor, can lead to changes in performance or even create barriers that are visible in another part of the system managed by a different actor. In addition, CCA will also include **research on long-term economic and societal trends, such as customer needs, human capital and skills, minority issue, such as gender, which must be taken into account by the different Innovation Programmes**.

Table 8 – The transversal Themes / CCA

SRRIA	MAAP
Attractiveness of rail and public transport	
Customer experience **Passenger Satisfaction**. Provide European rail customers (passenger and freight) with seamless, efficient and cost	WA1 "Long Term needs and socio-economics research" is covering these topics but the level of funding is limited and will not allow to engage into large activities on, for example, new business

effective end-to-end journeys in a safe and secure environment. **Passenger Experience**. Enhance the actual and perceived experience of every European railway passenger through smarter, cleaner and more engaging and appropriate facilities and services. **Passenger Comfort**. Constantly improve the amount of passenger comfort for each type of journey; the short commute to the long leisure journey, both on and off the train. **Passenger Access.** Introduce means of providing improved access for people of varying age, social category, life characteristics and level of mobility, taking account of user acceptance of innovative technical solutions. **Passenger Value for Money**. Demonstrate that customers receive value for money along with an increasing amount of informed choices to allow the customer to choose the best value service that meets their needs. **Passenger Priorities**. Sustain and exploit an increasing level of timely feedback received from European railway customers. Appraise actual and predict future performance to increase the ability to anticipate and quickly manage customer needs and to report on trends. **Freight Priorities**. Deliver to freight customers a responsive, yet flexible, cost effective, monitored and where appropriate, integrated	**models.**
Strategy and economics **Passenger Experience**, especially in areas such as : Urban mobility ; moving large numbers quickly and efficiently Modal integration ; ease and speed of changing between modes Delivering a 'single feel' to the Pan-European railway Improving robustness and resilience of the rail segment of end-to-end journeys **Customer Oriented Business,** **Customer Attraction** **Customer Access** to the railway, specifically for: Modal interchange for passengers with Reduced mobility (PRM) Improved access to rail services for a wider range of social groups Development and delivery of technology and innovation that enhances independence of and the ability for currently disadvantaged customers to use the railway **Integrated Information** **Freight Competitiveness**, New and novel freight wagons and associated loading and unloading Cross-European means of coordinating, managing and Exploiting freight operations Smart freight terminals able to move freight between modes in a timely and efficient manner Novel approaches to new freight services such as increased use of automation; use of passenger services for light freight. Improved freight-related information services to track, manage and secure freight throughout the rail segment of its journey **Affordable travel** Technology and innovation to reduce the overall cost of travel Improved capability for service providers and operators to dynamically tailor services to match need Environment and Safety associated with Strategy and Economics constantly improve the European railway's 'green credentials' through increased energy efficiency, reduction of waste, use of environmental friendly materials and so on. Ensure that the railway system is capable of managing weather extremes and climate change Increase the overall safety of the railway be removing or reducing safety risks Standardize, and where possible reduce procedures, regulations and standards ssociated with security and safety.	**WA1 – Socio economics and SPD** **IP4** **IP5 - All the SRRIA topics on Freight are to be tackled in IP5.**

In conjunction with route to market, Faster Time to Market sees the need for: Improved ability to quickly assess and realize the potential value of new technology and innovation A pan-European method to measure the (readiness) state of technology An improved means to promote and share novel technologies and innovations Improved ability to adapt or adopt technology and innovation from other business sectors	
A whole system approach: capacity, performance, safety	
Capacity, performance and competitiveness	**WA3 - Safety, Standardization, Smart Maintenance and Smart Materials** **WA3.2 – Standardisation** **WA3.3 - Smart Maintenance**
Safety (including certification) and security	**WA3.1 – safety**
RTSE	**MAAP**
Security	
System architectures - cyber threats could be minimised by resilient architectures and by additional layers of security including sophisticated firewalls between operational systems	**IP1 - TCMS** **IP2 - Adaptable communications for all railways** **IP2 - Moving Blocks** **IP2 - Fail-Safe Train Positioning** **IP2 - Traffic management evolution** **IP2 - Smart radio-connected all-in-all wayside objects** **IP2 - Cyber Security** **IP4 - Interoperability Framework** **IP4 - Booking&Ticketing**
Automatic back-up and dual redundancy - should be built into all key systems	**IP2 - Adaptable Communications for all Railways (redundancy)** **IP3 - Enhanced Switch & Crossing System (redundancy)** **IP4 - Trip Tracker (backup)**
"Internet of things" as a basis for emergency response	**Not covered**
IT systems such as those used by customers on trains or in stations, should be independent from key operational systems especially those with a safety-critical impact	**Not covered**
Active and passive systems to provide constant vigilance against terrorism and cyber-attacks, supplemented by trained staff	**IP2 - Cyber Security** **IP3 - Future Stations**
Interface with security systems and police and other law enforcement agencies	**Not covered**
Safety	
A range of continuous improvements and progressively automating systems such as CCC will lead to a positive impact on operational efficiency and safety and customer satisfaction and attraction	**IP2 - Railway network capacity increase** **IP2 - Traffic Management Evolution** **IP2 - Smart radio-connected all-in-all wayside objects** **IP3 - Enhanced Switch & Crossing System** **IP3 - Next Generation Switch & Crossing** **IP3 - Proactive Bridge and Tunnel Assessment, Repair and Upgrade** **IP3 - DRIMS** **IP3 - RIMMS** **IP3 - IAMS** **IP3 - Smart Power Supply** **IP4 - Interoperability Framework** **IP4 - Travel Shopping** **IP4 – Booking &Ticketing** **IP4 - Trip Tracker** **IP4 - Travel Companion** **IP5 - Freight Electrification, Brake and Telematics** **IP5 - Access & Operation** **IP5 - Novel Terminal, Hubs, Marshalling Yards, Sidings** **IP5 - Autonomous train operation** **CCA - WA 3.1 - Safety** **CCA - WA 3.3 - Smart Maintenance**
Collaboration tools to foster the effective management of the critical interfaces between all parties in the railway sector	**Not covered**
A harmonised process at European level will drive the verification and certification / authorisation of Safety Management Systems,	**"Yes, e.g.:** **IP1 - all**

vehicles etc.	IP2 - all ... IP5 - New freight propulsion concepts CCA - WA 3.5 - Virtual Certification
Campaigns to increase risk awareness	Not covered
Robust programs of level crossing closure	IP2 - Virtual Coupling ~ (study of new risks only)
Intelligent and consistently applied fall-back systems to assure safety during degraded mode must be routinely designed into every critical sub-system and component	IP1 - Doors and Access Systems IP2 - Traffic Management System IP2 - Fail-Safe Train Positioning IP2 - On-board Train Integrity IP4 - Booking & Ticketing

9.9 SRRIA priorities not covered by Shift2Rail

The main challenges of the railway sector as a transport way of transport in Europe and an important industrial sector for the European economy are shared by the SRRIA and the S2R Master Plan: Reduce the cost of transport, offer better services, increase transport capacity, contribute a more environmentally friendly world.

It is also important to remind that the driving point of SRRIA is not to start from a white sheet of paper and to re-invent a new guided transport system but to make the existing one working better at a lower cost for the benefits of the European citizen and economy.

The objective of the SRRIA was to identify domains of paramount importance to the railway sector for its future whereas the S2R/MAAP is a 7-year implementation program of activities. Because of that time schedule for the S2R implementation plan (there was also budget constraints) and the longer prospective view of the SRRIA, some SRRIA domains/topics are not tackled at all by S2R MAAP. Another reason results from the strategic decision of S2R investors to concentrate on development that could lead to tangible outputs (validated pre-products) within the S2R life time. However, for some topics/domains, even if research activity is going to be carried out, work will have to be continued beyond S2R in order to transform that first investment into concrete results that will impact the railway transport system.

In order to present the SSRIA priorities not covered by the S2R MAAP, the S2R structure is taken.

9.9.1 Rolling Stock (IP1 and IP5):

All major thrusts of R&D activities identified by the SRRIA will be worked out during S2R.

S2R is making a large investment in the application of the Silicon-Carbide technology (still emerging in terms of availability of high power chips) that will result into more reliable, more energy efficient traction drives. For experts in Power Electronics, the ultimate goal is the use of diamond. It is still a low TRL work carried out in academia labs but the sector should keep an eye, in a long term prospective, on the development of that electronic material.

The SRRIA has identified innovative propulsion fuel such as hydrogen (based on fuel cells). That new type of propulsion with as little as possible environmental impact has been and is currently studied by the automotive and the bus industries. During the last decade, tests have been carried out to demonstrate its feasibility, however with no commercial development. That technology has to be followed carefully by the rail sector in order the evaluate correctly the advances made in terms of RAMS and LCC for a “heavy duty” application. As the operational implementation lies beyond the S2R timing, this domain is not covered in the MAAP.

The SRRIA has also identified the issue of multiple power sources, including Energy Storage System (ESS) on-board to reduce energy cost. Work has already been carried out for passenger RS, e.g. with autonomous (catenary free) tramways. Different technologies do exist (with some evolving rapidly so that one technology that seemed to be the good one at a certain time, is not anymore the best some time later) but not one technology fits all needs. Besides the question of the location of ESS (where to put it on train and not reducing space for passengers), the business model has not yet been proved. The topic is tackled in S2R/IP2 to develop the "last mile locomotive" so that the cargo can be delivered even if the electrified infrastructure does not exist.

The SRRIA has identified "Environmentally friendly and energy efficient HVAC". Train auxiliaries are representing around 30% of the overall energy cost of a train with HVAC taking the lion's share. This domain is heavily invested by other sectors, e.g. the automotive industry, for which increasing the energy efficiency of HVAC, is even more crucial. The rail industry is following closely the development in that domain so that the rail sector can benefit rapidly from major advances and synergies, always considering their own specification, needs and constraints.

As auxiliaries are passive systems, i.e. they "deliver" when necessary, and based on the outputs of the "Smart Grid revolution", optimization and development of intelligent management auxiliaries have been identified as a potential for increasing energy efficiency. This cannot be achieved without a proper knowledge of the energy flow within a train at the micro-scale.

The freight RS topics identified by the SRRIA is covered by the S2R/IP5.

The domain "PHM (Prognostic and Health Management)/Condition-Based Maintenance" has been identified by the SRRIA as of importance. Based on the fact that products implemented by manufacturers are in operation and that it is not a real R&D activity but an implementation one, S2R has concentrated on the inclusion of the maintenance specifications in the design phase of new component/sub-systems.

9.9.2 Control Command and Communication (IP2 and part of IP5)

Many topics identified by the SRRIA are going to be tackled with the implementation of the S2R/MAAP. It does not mean that concrete results (in terms of validated prototypes in operational or near-operational conditions) will be achieved as some S2R TDs are quite exploratory such as the TD "Virtual Coupling". Further activities will have to be carried out in parallel to project funded under the Open Calls budget line.

9.9.3 Infrastructure (IP3)

S2R is tackling all the sub-components of the rail infrastructure with, for some of them, i.e. Switching ad Crossing, Tracks, with TDs on a medium term prospective to increase the reliability of existing assets that have long life cycles (50-100 years) and a long term one with a more exploratory approach.

S2R is going to work on the infrastructure maintenance issue through a step-wise and fully integrated approach.

An issue not covered by S2R is on the security of the rail infrastructure. They are large unattended assets quite vulnerable as the stealing of copper wires is showing to-day.

9.9.4 IT for rail (IP4)

It is the first time within the history of EU Framework Programs that this topic is tackled comprehensively in order to deliver solutions validated through operational implementation. The IT ecosystem is a rapid changing one with new technologies emerging and new applications that can change rapidly a considered well-established business model. The S2R IP4 members are covering the full chain of values.

The IT topic is also covered in IP5 dedicated to freight.

9.9.5 Freight (IP5)

The S2R IP5 is covering all topics identified in the SRRIA.

The Urban Freight issue mentioned several times in the SRRIA is not covered by S2R as there is no clear business model and consequently no operator ready to invest in R&D.

9.9.6 CCA

"Technical" issues identified in the SRRIA, such as Noise & Vibration and Energy Efficiency are well covered by S2R. Thus, energy efficiency will positively impact the cost of operations and thus is a component of the S2R cost KPI. Noise & Vibration is also well covered by S2R.

As S2R is mainly technology driven, a certain number of topics identified in the SRRIA are not covered at all such Transport Economy, New Business Models, etc. R&D activities are crucial for the future of the rail transport in a rapidly evolving world in which new offers of transport emerge.

10 CONCLUSIONS

The European Railway transport system is fully dedicated to serve Customers, both passenger and freight, with the highest level of services at the right price. The competition from other transport sectors will require the railway increasingly to focus on better satisfying current customers to attract new ones, including by expanding both passenger and freight services and to be competitive in terms of fare.

The railway transport needs to address deeply the following five main challenges to enhance rail's market share dramatically, leveraging its basic advantages:

- Increase rail attractiveness for passengers and goods (connectivity, fluidity, passenger experience, service extension …)
- Increase rail competitiveness, reducing operational costs, as some non EU countries are managing to achieve good results in this respect
- Sustain and further develop the environmental friendliness of rail decrease time to innovation through revisiting standardization and regulations, and moving to open technologies (communication, information systems, financial transactions/ticketing, localization, automatic driving)
- Sustain and further develop the railway sector robustness, through education, training, and improvement of processes and tools for design, manufacturing, and operation
- Effectively leveraging new technologies such as digitalization, new materials, big data, energy storage and efficiency, and many others.

For the period 2014-20, a certain number of EU Programs have been established and can be used by the Railway Transport system to achieve its key objectives.

10.1 The role of H2020 and the Connecting Europe Facility

The overarching goals of establishing an internal market for rail and of strengthening the competitiveness and attractiveness of the rail sector, while also sustaining the position of the European rail industry, will necessarily imply the emergence of innovative approaches in business models, services and products, throughout the whole rail value chain. This will, in turn, require a dramatic increase in research and innovation efforts. **A key objective of H2020 is to improve the efficiency of EU funding** and better address societal challenges by pooling together existing R&I efforts and expertise, namely through Public-Private Partnerships (PPPs) in the form of Joint Undertakings. In line with this, the Shift2Rail Joint Undertaking (S2R JU) was established by Council Regulation (EU) No 642/2014 of 16 June 2014. The S2R JU is a public-private partnership, providing a tool for the actors of the European rail system to work together with a view to driving innovation in the years to come by implementing a comprehensive and coordinated research and innovation strategy.

The Connecting Europe Facility (CEF) is the EU's new programme for investing in EU infrastructure priorities in transport, energy and telecommunications (digital networks) with a view to completing the European single market and boosting Europe's competitiveness.

Eligible projects will include activities aimed at removing bottlenecks on transport routes and bridging missing links, in particular on cross-border connections, as well as those that contribute to the deployment of the European Rail Traffic Management System (ERTMS) on principal routes of rail freight corridors and that support rail interoperability.

The CEF will also serve to deploy new technologies and innovative transport solutions with a focus on decarbonisation, safety, sustainability, accessibility, multimodality, efficiency and improved operation and management of the network.

10.2 The SRRIA ecosystem

The ecosystem in which the SRRIA was developed is based on Cohesive Working groups working within FOSTERAIL with experts from manufacturers, operators, academia and user groups working openly and transparently to develop 10 part roadmaps (see Chapter 5). That is the very essence of the SRRIA and its ten FOSTERAIL roadmaps, paving the way to develop the railway sector in Europe for the decades to come, far beyond S2R, to make it sustainably competitive and to improve overall transport efficiency in Europe.

The main challenges that were identified as shaping up the SRRIA framework are

- Passenger experience
- Customer Orientated Business around Customer Attraction and Customer Access
- Pan-European Value for Money
- Faster Routes to Market
- Integrated Information
- Freight Competitiveness
- Affordable Travel
- Environment and

- Faster Time to Market

Rail research and innovation policies at the European level will be strongly driven by the need to strengthen European rail industries within the challenge a competing global rail market, successfully delivering large rail projects bids, including turn-key ones. On the other hand, rail research and innovation policies increasingly reflect a shift to rail mode with more restrictions on road transport and the phasing out of conventionally fueled vehicles in urban areas.

10.3 Final conclusions

The SHIFT2RAIL MAAP is the backbone of the Rail Sector R&D for the coming years.

Because S2R has to deliver validated Technical Demonstrators by the beginning of the '20s and because of budget limitations, priorities have been made whereas the ERRAC SRRIA has a longer perspective. Consequently, although the spectrum of topics/domains covered by the S2R activities is large, some topics are not going to be tackled by S2R.

Following the S2R structure, the following topics have been identified as **not** covered by S2R and that should be supported by H2020:

- Rolling Stock:
  The S2R IP1 is rather comprehensive as it covers all major sub-systems of a train. Therefore some topics have been identified as challenging for the long-term future of the Rail business and not covered by the S2R activities.
  - Hybrid Traction Energy: Light rail in some cities is already operating with on-board Energy Storage System (ESS) to avoid visual pollution of overhead power supply. The development of enabling technology of ESS must be followed very closely by the Rail Sector for main lines applications, keeping in mind that "one size won't fit all needs"
  - Innovative Propulsion Traction, e.g. based on hydrogen energy, that will require constant investment over a long period to make it a reliable and cost-effective operational traction system.
  - More efficient and smarter auxiliary equipment, e.g. HVAC: the sector must follow closely development made in other sectors to adapt them to the rail environment.
  - Enabling Technology: the future generation of power electronics materials i.e. diamond
  - The specific needs of the urban rail sector in terms of rolling stock – metros, trams, tram-trains – need to benefit from dedicated R&I actions as they are not fully covered by S2R, e.g. full standardisation (FFFIS) of on-board and wayside interface for automated metros (see also below), HVAC[14] and IT platform for Tram and Light Rail, new generations of Rolling Stock for urban rail segments, digital operation of every urban rail segment. Improved rolling stock maintenance technologies and procedures is another interesting aspect for urban stakeholders.
- Control Command and Communication:

[14] Heating, Ventilation and Air Conditioning.

The S2R IP2 agenda is quite comprehensive combining pragmatic TDs that will deliver solutions by the end of the Program and other that are more exploratory. No R&D topic has been identified to be supported by H2020 outside S2R activities in the case of mainline rail. In the case of urban rail, there is a strong need for R&I activities on CBTC systems, such as the standardization of interfaces (on-board and wayside) or performance improvements. Another topic which ought to receive H2020 support is the bandwidth allocation for urban rail (e.g. the SUG initiative of both urban rail and industrial partners).

- Infrastructure:
  The S2R IP3 is covering all major sub-systems of the mainline rail infrastructure with, for some of them, a medium-term perspective fitting within the S2R life span but also a longer term perspective e.g. Switching & Crosses and Tracks. Except the security issue of the rail infrastructure which is mainly an unattended asset, most of the topics are covered by S2R. However, some elements would benefit from being supported by H2020:
    - Smart removal strategies for outdated polluting existing infrastructure being historical legacy
    - Smart strategies to reduce pollution from infrastructure sources

The specific necessities of urban rail are also often out of the S2R scope and need to be addressed, in order to reduce the LCC of infrastructure and facilitate its maintenance by taking into account the specific operational requirements of each market segment. Other important topics in this case are: urban intermodal stations of the future; connecting airports with urban rail systems in order to improve urban public transport use and services for air passengers; Research on technical and economic factors for prioritizing investments in urban rail – how to choose between tram & light rail/metro and suburban/regional connections (and extensions); how to better connect major EU cities through regional and suburban railways to the TEN-T networks.

- IT Solutions:
  It is the first time that within an EU Program, this topic is comprehensively tackled. The S2R activities that gathered rail expertise and more important expertise outside the sector, will deliver step change solutions. As some partners investing in that domain are coming from outside the rail sector, they are following, and for some of them, investing new development. They are in a position to bring in new technologies and approaches.
- Freight:
  It is also the first time in the history of EU Programs that this domain is covered comprehensively with a longer term support than previous EU projects that were a patchy contribution to that issue.
  S2R is only addressing the main line freight issue and is not covering the urban freight issue.
- CCA:
  Most Work Areas of the CCA activities are covered by S2R. However, for the Rail Sector there is a clear need to anticipate the future evolution of the society as well as

the future emergence of new services that could negatively impact the sector business (not being a follower). H2020 should support R&D in economics, new paradigms that could impact business models.

Human capital that is vital for a sector has also to be supported by H2020. The first element that would be critical to ensure successful implementation of research and innovation results in the transport sector is a proper way of training people e.g. through improved and smart learning methods.

UITP and the urban rail community consider that as the urban rail operators and other relevant stakeholders and authorities have not been involved from the beginning in the S2R programming for these topics, it is necessary that H2020 offers other opportunities to look into these topics.